Pleistocene Deposits

of

South Carolina

Vanderbilt Univ.

Thesis

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With an Especial Attempt at Ascertaining what must have been the Environmental Conditions under which the Pleistocene Mollusca of the State lived.

BY

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A THESIS

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INTRODUCTION

The Pleistocene Period is of especial interest, as it corresponds to one of those periods commonly looked upon as marking a break in the geological record left man by fossils in the sedimentary rocks of the earth. There is evidence to believe that there was a long period of time between the last of the determined Paleozoic formations and the first of the Mesozoic, and another long period between the last of the Mesozoic and the first of the Cenozoic. Of these periods only a partial record, in way of a few widely scattered deposits, has been left. They are generally looked upon by geologists as periods of great and rapid changes in life-forms. LeConte and others put themselves on record as believing these periods of lost record, or at least the first of them, to have been periods of considerable glaciation, when, whatever deposits there were, were put down as drift or some other product of glaciation in such condition as to be completely obliterated in the long periods which have since elapsed. The Pleistocene, being evidently a period which was ushered in by the advance of the ice from the north upon more southernly latitudes, may throw some light upon these other periods of supposed glaciation. And as the Pleistocene can be studied to some extent from its fossiliferous deposits, one sees that the information gained from a study of the Pleistocene may be of some value in interpreting the probable conditions that existed during the periods of lost record between the Permian and the Triassic, and between the Cretaceous and the Eocene. So the Pleistocene has this interest in addition to those inherent in itself. In this paper, however, there will be no further mention of this particular phase of interest, but a study of such phases as concern the Pleistocene more directly.

Though deficient in those qualities which come by reason of respect and veneration for age, the Pleistocene is of very great interest as furnishing the link that connects the present life with the life of the recent geologic past. It exhibits the process by which ocean bed has been converted into dry land. It gives evidence of the descent of living forms from fossil forms, since its fossil forms have very many of their characters, even to the marking and colors of their shells, almost as well preserved as those of their descendants living

along the coast today. It is the period when, in the course of evolution, were ushered in those animals which were to be the contemporaries of man, 95 per cent. of Pleistocene forms, according to Lyell, being also recent.

With these thoughts in mind, the task of working on the Pleistocene formation in South Carolina has been entered upon gladly, though with many misgivings as to the writer's ability to deal with the problem as its importance demands. Of all the Coastal Plain region from Texas to New England, that portion in South Carolina has been, perhaps, least investigated. The true succession and extent of beds have, in many cases, not been fully determined. The extreme thinness of the Miocene, Pliocene and Pleistocene beds, and consequently the greater likelihood of their being entirely removed in places during periods of erosion, together with the almost universally low altitude of the surface with reference to the sea and the consequent absence of good sections or even many natural exposures of any kind more than a few feet deep, has made it very difficult to trace the succession and extent of these formations. For instance, the patches of Miocene in South Carolina that have been left from erosion indicate that this formation could not have been more than 150 or 200 feet at best, whereas in Texas to the southwest it is more than 2,500 feet thick, and to the north of the State it also gradually becomes thicker. In the region of North and South Carolina there seems to have been a region or belt of elevation or of minimum subsidence, perhaps since Triassic time. This relative elevation has caused a thinning of the successive beds since that time in this region. The tracing of the extent and succession of these formations has been engaged in by a good many investigators, from the time Lyell visited the State, in 1841-42, and before on up to the present, or to within the last two or three years, when Dr. L. C. Glenn of Vanderbilt University made some investigations concerning these formations in preparing a paper on "Artesian Well Prospects in South Carolina." The work done by these men will be briefly reviewed in this paper under the heading, "A Historic Review of the Work Done in the Region."

In preparation for writing this paper, the writer found it necessary to do some work in the field, collecting fossils and making observations of the localities where the fossils were found. During the summer of 1904, some time was spent along the coast of South Carolina in collecting Pliocene and Pleistocene fossils from well-known localities, and noting the country around such localities as

well as the succession of strata in the intermediate section where the marl bed is exposed. Some recent shells were also collected along the beach. No new exposures were sought out, for time was limited, and, too, such was not necessary for the investigation to be carried on. In most localities the observations of others were confirmed as to thickness and position of fossiliferous beds and other beds above and below. But at Young Island, the famous Simmons Bluff of geologic literature, the bluff was found somewhat changed from what it was when Tuomey, Holmes, Burns and others made collections there. The "storm of 1893" wrought some changes here as elsewhere along the coast, removing an area of about ten acres just along the bluff, as Mr. Geraty, the postmaster and one of the largest truck farmers there, a man of good memory, informed me. This, however, was far from being a disadvantage, as it gave a greater area of exposure and consequently greater facility for collecting. As this was the writer's first experience in collecting fossils, with the exception of collecting under different conditions from the Silurian beds about Nashville, Tenn., one can well imagine the delight with which the broad exposure of fossil shells was beheld, and with what eagerness shovel and sieve were brought into play. The exposure extends outward from the foot of the bluff a distance of thirty or forty yards at low tide. The length of the exposed bed along the margin of Wadmalaw Sound is a half-mile or more. Also at White Point Creek (Price's Creek) such great changes had taken place that the Pleistocene fossil bed located by Tuomey as on the right bank of the creek, a half-mile from the point where the old Kingston country road crosses the creek and plainly within view of the ocean beach, could not be found at all, though four or five hours, with the help of Mr. Sessions and his two boys of that neighborhood, were spent in the effort to locate it. Exposures were looked for everywhere within proper limits, and numerous small holes three or four feet deep were made over an area a half-mile long and several rods wide, extending from a quarter of a mile of the old Kingston road almost to the beach, but the shells sought for were not found. The supposition is that the bed had been so deeply covered with sand by the storm of 1893, or some other, that the holes made did not reach down to it, or else that the bed itself had been swept away and destroyed. Storm-driven waves may easily accomplish this in case of a bed of limited area as this, from Tuomey's description, seems to have been. In the proper place in this paper will be given descriptions of the various localities from which Pleistocene shells have been collected.

Though a limited discussion of the Pleistocene of the whole Atlantic Coast from Maine to Florida will be given, and a discussion of the succession, relation and extent of the Coastal Plain formations in South Carolina will be attempted, the main object of this paper is to attempt an investigation of what must have been the environmental conditions under which the marine mollusca lived during the Pleistocene Period in the neighborhood of South Carolina. Temperature, depth, shore, bottom, current and other conditions that then existed will be sought for by comparison with such conditions today, upon the basis that a species now favoring a particular habitat, if then in existence, favored the same kind of habitat. Since 95 per cent. of Pleistocene species are regarded as recent, as commonly accepted, one easily sees that if exact knowledge were at hand concerning the habitats of living species a fairly just interpretation of Pleistocene conditions could be arrived at. In connection with this problem tables have been made of all South Carolina Pleistocene mollusca so far as the writer could gather the information, the work of Holmes and Dall being drawn upon to make the tables as full as possible. So far as the writer is aware this is the first attempt made at just this problem for the Pleistocene, and he feels that his effort is very imperfect, but trusts that the labor may be of some service, however slight.

The material collected during the summer was sorted and classified during the fall and winter at Vanderbilt University. Dr. Dall's work in the Proceedings of the Wagner Free Institute of Sciences was followed in naming the different species found. There are some species, however, which are not given by Dall; these have been named as Holmes named them in his "Post Pliocene Fossils of South Carolina." Just here it must be stated that during the year 1903-04 a class in Paleontology at Vanderbilt University, of which the writer was a member, worked up a lot of shells from the Stono River beds. This Stono River material has been used in making out the tables. In addition, material from Cornfield Harbor, St. Mary's County, Maryland, has been ready at hand and used for purposes of comparison. A list of the Cornfield Harbor fossils, increased by a few additional forms from Conrad's list from that same locality, will be given. So also will be given lists of Pleistocene fossils from the Florida beds, and from the beds of Sankoty Head, Massachusetts, and attention called to the similarities or differences of these fauna from the different localities.

Inasmuch as no one formation can be treated independently of

those just above it or just below, the Pliocene of South Carolina has also been studied to a limited extent in its relation to the Pleistocene. Though material was collected from the Waccamaw beds, time has failed in which to work it up, and the work done by Johnson on these deposits has been largely relied upon in this part of the paper. Tuomey and Holmes, in their "Pliocene Fossils of South Carolina," have classed as Pliocene not only the well-determined Pliocene of the Waccamaw, but also the Miocene about Darlington, Sumter and elsewhere. Their otherwise excellent volume is, by reason of this confusion, well nigh useless for the purpose here intended. Only those species distinctly mentioned as coming from the Waccamaw beds can be depended upon in arriving at any safe conclusion. The tables already mentioned will also show the relation which the Pleistocene fossils bear to the Pliocene and to the Miocene, though no attempt will be made to prepare separate lists of the Pliocene and Miocene fossils of the State.

In order to bring the scope of the paper more clearly before the mind, it is well to recapitulate, having regard to the sequence that has been followed in the discussion of the various phases of the subject. Following this introduction, the paper begins with a discussion of the work of the early investigators in the region and a historical review of the work done from that time to the present. This is followed by a chapter on the geographic distribution of the Pleistocene or Columbia formation along the Atlantic Coast from Maine to Florida. Then comes a more particular discussion of the Pleistocene of South Carolina, together with descriptions of Pleistocene fossil localities with sections, wherever possible, showing stratigraphic relations. After this come the tables, giving the Pleistocene species found in South Carolina with localities; other ages in addition to the Pleistocene in which they have been found, and the relative scarcity or abundance as Pleistocene fossils; the depth range and shore and bottom conditions of the living representatives of the Pleistocene fossils, also their extreme northern and southern geographical ranges. Just after this a discussion of the tables and conclusions from the information there gained are given. The bibliography at the end is not intended to be exhaustive, but embraces only the more important articles that have been published on the subject. Especially is this true in regard to the publications concerning the Pleistocene of the whole Atlantic Coast; only a very few of these are given.

In making acknowledgments for kindnesses shown me while engaged in this piece of work, I wish first of all to speak of the help, in way of encouragement and suggestions, that my instructor, Dr. L. C. Glenn, has at all times most cheerfully given me. He has given me the use of his own geological library, and where a book needed could be obtained neither from his library nor from that of the University, he borrowed it for me from elsewhere. His own collections of fossils and those of the University have been at my disposal in making out lists and in preparing tables. In the discussion of the Geographic and Stratigraphic relations of the Pleistocene of the State, his observations and investigations have been of great value.

My thanks are due the University for financial assistance while collecting fossils, and are most heartily given. I wish also to acknowledge the kindness of Dr. W. H. Dall, of Washington, in promptly identifying certain species sent him.

I. HISTORICAL REVIEW.

The Atlantic Coastal Plain of the United States has been an object of interest and study to geologists since the time the pioneers of American geology, Mitchell and McClure, first discriminated the region and aroused in others the desire to investigate its problems. It was due to investigations in this region and to efforts at interpreting the records of the ancient life in its strata that Conrad, Tuomey, the Rogers brothers, Holmes and many others, in the middle of the century just passed, gained their renown. Later Hilgard in the Gulf region, Cook in New Jersey, and others in the region between and in New York and New England studied the succession of strata as revealed by the fossil forms embedded in them, and so impressed their ideas of classification and nomenclature that these are still largely adhered to. In recent years McGee, Salisbury, Chamberlain, Dall, Shattuck and others have wrought in this field so perseveringly and so thoroughly that it may be said that no section of our country has been more thoroughly investigated than has the Costal Plain.

North Carolina has the honor of being the first State of the Union to authorize, at its own expense, a survey of its territory "with the desire of developing its resources and enlarging the boundaries of human knowledge." South Carolina was the next to fall in line in this commendable work. Whatever may have been its shortcomings since, the State made a good start. By order of its legislature, Mr.

Lardner Vanuxem, in 1826, made a report on a geological and mineralogical survey of the State. A collection of minerals from different parts of the State was placed in the Museum of South Carolina College. Vanuxem wrote a paper on the Tertiary and Cretaceous formations of South Carolina, and this appeared in the Journal of the Academy of Natural Sciences, Philadelphia. He was the first to note the occurrence of the Pleistocene at Charleston, collecting some of the fossils of this age from a well there and taking them to Philadelphia. But before 1826, even as far back as 1731, Catesby wrote something of geological interest, calling attention to the encroachment of the sea upon the land. This was a matter of concern at that time and attracted the attention of many, especially those of a scientific turn of mind. Closely akin with this question was another, the subsidence of the coast. Bartram, in his "Travels," was the first to point out evidences of subsidence—the submerged stumps of trees, common along the coast. Lyell and others noticed these submerged stumps and came to the same conclusion, that these stumps show a vertical submergence of the land. This mention of the work of Catesby and Bartram has been made simply to show that, very early in the history of the State, men were making contributions, though slight, to its geology.

In 1832 Conrad determined the existence of the Miocene in the State. This determination rested upon some fossils collected at a point just below the junction of the Wateree and Congaree rivers. He also attributed certain deposits on Cooper River to the Tertiary.

Lyell, the leading geologist of his time, in 1841-42 gave a few days' investigation to the strata of the Cretaceous and Tertiary formations of the State. He went down the Savannah River from Augusta, examining the exposed beds as he went. He also investigated the region from the mouth of Cooper River northwest to the Santee, where that stream is joined by the old canal, a distance of forty miles, and then on up the Santee to Half-Way Swamp. Along the Cooper and on the Santee, he traced the white limestone of the Eocene formation, and at Stout's Creek he found this to disappear under a newer formation, the Buhrstone. The results of his investigations are mentioned in a general way in his "Travels in North America," and more particularly in his "Observations on the White Limestone and other Eocene or Older Tertiary Formations of Virginia, South Carolina and Georgia." He referred to the post-Pliocene, the marine shells of eastern South Carolina, which "differ in no way from those of the adjoining coast," and are contained in

deposits of sand and clay, "put down when the land stood lower than today, while the temperature was little different from that of today."

After Vanuxem's report of 1826, nothing more was done by the State in the way of a survey until 1842. In that year, by authority of the Legislature, Mr. Edmund Ruffin, of Virginia, was employed to make an agricultural survey of the State. He conducted the work with great ability, and his report is valuable not only as an agricultural report, but also as a source of geological knowledge, especially the discussion of the marl beds. He relied largely on characteristic fossils in determining the age of the different marl beds investigated. These marl beds were grouped into four classes: (1) The Peedee bed, containing *Belemnites Americana* and *Exogyra costata,* and lying in the region bordering on the Great Peedee and some of its tributaries, as Black River, in a continuous area in Marion, Williamsburg and Georgetown counties. This formation was evidently regarded by him as Cretaceous. (2) The next oldest formation of marl, the Great Carolinian bed, so called by him because of a difference of opinion as to its age, Vanuxem, Conrad and Morton considering it Upper Cretaceous and Lyell including it in the Eocene. The following observations were made in regard to this bed: That, though the character of the bed changes from place to place, still for the most part this marl is of a dingy yellowish white color, or pale buff of different shades; that the dip of the surface is generally from north to south, and does not differ greatly from the general slope of the country; that it extends from just east of the Santee to the Savannah and beyond, its northwestern limit being a line almost parallel to the line of falls of the rivers and about twenty-five or thirty miles below, and that eastwardly it stretches to and beneath the ocean and is overlaid in places by younger beds. (3) The Miocene marls, occurring in extensive patches lying upon and immediately in contact with the older Pedee marls on the west side of Peedee River and extending into Darlington and Florence counties, being exposed along Swift and Black creeks. He also notes an isolated patch of Miocene marl on Goose Creek a few miles above its junction with Cooper River and about twelve miles from Charleston. (4) Post-Pliocene marl beds, which lie between high and low tide wherever yet (at that time) observed, probably with the exception of that under and near Charleston. This formation generally presents but a thin bed, about three feet thick, containing the shells of such animals as now live in and mostly if not entirely belong to the neighboring ocean waters. Beds of post-Pliocene fossils were found

along several tidal creeks emptying into the South Edisto, at Distant Island, about four miles south of the town of Beaufort, at Lady's Island, three miles east of Beaufort, and at Doctor's Swamp, on John's Island, where was found a bed five miles in length. Underlying Charleston, he observes, at a depth of about fifteen feet, is a bed of these shells, reached by the "fire wells," and exposed in several places around the city, as at Haddrell's Point, and at several of the bluffs on Ashley and Cooper rivers. Ruffin also states that some of these beds are several miles back from the shore line, and are often overlaid by still later deposits of marsh soil several feet thick and sometimes by fine sandy earth. The list of post-Pliocene fossils prepared by Prof. L. R. Gibbes, of Charleston College, is of fossils from the bed underneath and near Charleston, and is as follows: *Natica duplicata, Nassa obsoleta, Nassa vibex, Cerithium dislocatum, Pyrula carica, Oliva Sayana, Oliva mutica, Ovula acicularis Fissurella alternata, Ostrea Virginica, Pinna seminuda, Arca incongrua, Arca pexata, Arca ponderosa, Cardium maculatum, Donax variabilis, Tellina alternata, Lucina divaricata, Venus mercenaria, Cytherea concentrica, Mactra lateralis, Lutraria canaliculata, Balanus ovularis* (?), *Scutellum quinqueforme* (?).

After one year's service Mr. Ruffin resigned, and was succeeded by Mr. Toumey. In 1844 it was found advisable not to attempt an agricultural survey distinct from matters geological. Tuomey was, therefore, asked to make a report upon both the agriculture and the geology of the State. As the work progressed it became more and more largely geological, and the final report of 1848 is titled "Geological Survey of South Carolina." From the requirements of the case, the report had to be partly commercial, but it is of much value for its scientific weight. It is by far the best thing on South Carolina Geology; in fact, the only thing of any extent. All sections of the country are treated. The coastal plain of the State is here, for the first time, systematically described with an attempt at scientifically classifying the beds. The extent of the Cretaceous, Eocene, Pliocene, and Pleistocene formations is traced and lists of fossils from each given. Tuomey was greatly assisted in this work by collections of fossils made by college professors, lawyers, physicians, preachers and others of Charleston and the localities around. It seemed almost a fad among cultured people to collect fossils in those days. Several of the number were intelligent collectors, and their observations were also of value to Tuomey in preparing his treatise. Such men as Dr. R. W. Gibbes, Dr. Edmund Ravenal, Prof. L. R.

Gibbes, Dr. Hume, of the Military Academy, and Dr. Burden, of John's Island, were no mean helpers, and contributed largely to the success of the work. In regard to the assistance given by Prof. F. S. Holmes, Tuomey's own words are: "It would be impossible, if it were necessary, for me to separate my own labors from those of F. S. Holmes, Esq., both on the Ashley and in the post-Pliocene of the State. His fine and valuable collections of fossils were placed at my disposal, and I have used them without reserve. It is chiefly through his labors that the Ashley has already become noted for its organic remains." Tuomey assigned the Coastal Plain formations to four classes or ages: Cretaceous, Eocene, Pliocene and post-Pliocene. We are at once struck by the absence of the Miocene from this enumeration. He regarded the Miocene, now clearly established about Darlington and Sumter, as Pliocene, and so put both Miocene and Pliocene as Pliocene. In his map to show extent of formations he uses the word *Miocene* for all that extent of territory which he has carefully designated *Pliocene* in the treatise, but this is clearly a misprint.

The Cretaceous was traced, by means of characteristic fossils, throughout the region described by Ruffin under the "Peedee Marl," and in addition was found exposed in patches farther to the west in Darlington and Florence counties along Lynches Creek to the mouth of Sparrow Swamp, and farther to the east it was found on Little Peedee River just where it is joined by Lumber River, and on the Waccamaw, in Horry County, from three or four miles below Conway to within eight or ten miles of the North Carolina line. His supposition was that the Cretaceous underlay that whole section of country from its most western exposure at Sparrow Swamp on out to and beneath the ocean. The Eocene was divided in this survey into three groups: (1) The Buhrstone formation underlying the calcareous beds described by Lyell and by Ruffin. The Buhrstone was described as being 400 feet thick, its upper portion containing silicified shells, being largely exposed up to the line drawn from Columbia in a direction a little south of west by Lexington Courthouse and Aiken, on to Augusta, and its southern exposure running in an irregular line across from Stout's Creek on the Santee to the Lower Three Runs on the Savannah. (2) The Santee beds, the thick beds of white limestone, marl and greensand, whose northern or western exposures coincide with the line just given for the southern limit of the Buhrstone. (3) The Ashley and Cooper beds, the newest Eocene beds in the State, overlying the Santee beds just mentioned,

these two series of beds having a combined thickness of about 600 feet. His three divisions of the Eocene correspond to Ruffin's "Great Carolinian Bed."

Tuomey's Pliocene deposits are irregularly scattered over the State, and it must be borne in mind that his Pliocene includes both the Miocene and the Pliocene as now distinguished. First will be considered that part of his Pliocene which is known to be Miocene. He found it in patches resting on the Eocene at Goose Creek, then about Sumter, Darlington, and Florence, especially on Lynches River, Black Creek, and Swift Creek. On the Peedee he also found exposures of what he called Pliocene. Though this region has not been thoroughly investigated, the supposition now is that this too is Miocene. Now will be taken up what has clearly been shown to be Pliocene. On the Waccamaw the Pliocene was found exposed from a few miles above Conway on up to or very nearly to the North Carolina line. He gives two sections of the river bank which are, in the main, characteristic of the entire length of the formation exposed along the Waccamaw:

(1) The section three or four miles below Nixonville at the old William Nixon Place:

Yellow sand, showing false stratification and very undulating on the surface. . .. .30 to 40 feet
Yellow Pliocene marls. . .. . 8 to 12 feet
Beds of Cretaceous formation. . .. . 8 feet

(2) Section on Tilly's Lake at Nixonville:

Overlying loose sand and clay. . .. .30 feet
Pliocene marl. . .. .10 feet
Cretaceous formation, *Exogyra costata*. . .. . 2 feet

It may be well to state just here that Johnson found the Pliocene along the Lake at Conway for some distance up the stream, and also found it lower down the Waccamaw than did Tuomey. Lists of fossils from the several Pliocene localities were given and all summed up in the tables here reproduced:

	Number of species.	Species recent.	Percent.
Brachiopoda.	1	0	
Gastropoda.	78	39	50
Lamellibranchiata.	109	47	43
Cirripedia.	2	1	50
Total.	190	87	46

Upon this percentage he rests his proof that these beds are Pliocene, this being about the percentage of the fossil shells that are also recent, claimed by Lyell and other English geologists as necessary to constitute the Pliocene.

The post-Pliocene was, in this survey of Toumey's, treated more fully than ever before in the State, and perhaps more fully than this formation had been treated anywhere else along the Coastal Plain. The work of Ruffin was reviewed and several additional localities added to the list of exposures. "It is composed of beds of sand, clay and mud, containing fossils, the whole amounting to about sixty feet in thickness, overlapping the Pliocene beds of Horry and Georgetown, and on the rest of the coast those of the Eocene." The section of one of the wells that cuts through the post-Pliocene at Charleston shows:

Sand below which water is found	5 to 6 feet
Quick sand and clay, remains of trees	9 feet
Sand and small shells	1 foot
Gravel and oyster shells	2 feet
Mud and Conch shells	2 feet
Fine close clay with young oyster shells	3 feet
Pluff clay with scales of mica, sand to Eocene bed	20 feet

The following general observations were made: That though the fossiliferous bed in this section is eight feet thick, it is rarely more than four feet thick in its exposures along the coast; that this is typical of all sections along the coast, the fossiliferous bed being everywhere overlaid by heavy beds of sand, closely similar to those being formed along the coast at present; that the fossiliferous formation extends back from the coast about ten miles, thinning out at an elevation a few feet above tide; that its boundary is irregular; that this bed underlies the whole coast, and is seen wherever the streams remove the beds by which it is covered. He found the formation exposed on Price's Creek (now called White Point Creek) in Horry County about a half-mile from the beach and elevated five feet above tide. The shells here were principally *Venus mercenaria, Ostrea Virginica* and *Arca incongrua.* Also in several other places in Horry County and in Georgetown County exposures were found. At Laurel Hill bluff the fossil bed was observed eight feet above tide, and in digging Winyah Canal post-Pliocene shells were met with, showing that the surface sands are underlaid by it. The nature of the formation here was found to be very much like that of the bed

underlying Charleston. From this region the formation was traced along through Charleston County by several exposures. On the Santee at Mazyck's Ferry, the bed corresponds to the stiff blue clay penetrated in the wells at Charleston. It was found on the Ashley near Bee's Ferry, about a quarter of a mile from the river and five feet above tide. It was also investigated on the shores of several inlets just below Charleston and on down to Beaufort; on Stono River; on Abapoola Creek, and elsewhere on John's Island; on Wadmalaw Sound at Simmons Bluff; and at several places around Beaufort. Taking all these exposures from White Point to Beaufort into consideration, Tuomey was evidently right in saying that the fossiliferous beds of the post-Pliocene underlay the sands of the whole South Carolina coast and extended inland eight or ten miles.

In addition to the discussion of these four formations, the alluvium deposits and the changes along the coast were discussed. Tuomey did not assent to the opinion that the coast region is gradually subsiding, but rather thought these appearances of subsidence were due to the encroachment of the sea upon the land.

The plates of fossil forms which were to make a part of this volume were so badly used by the printers that it was decided to dispense with them. This defect in the volume, according to Professor Holmes, was the object of common regret to the members of the American Association for the Advancement of Science, which held its meeting of 1850 at Charleston. At the urgent solicitation of such scientists as Agassiz, Gould and Bache, Tuomey and Holmes undertook a separate publication of these plates, together with descriptions of the fossils figured. The result is their "Pliocene Fossils of South Carolina," issued at Charleston in 1857.

In the meantime Professor Holmes had been at work on the geology of Charleston and the immediate region around the city. His work was mainly on the Pleistocene formation. On Ashley River, on Wadmalaw Sound at Simmons Bluff, on Stono River, on Abapoola Creek, and Doctor's Swamp and elsewhere on John's Island, and at other localities, he had made collections of fossils of this formation. As a result of this study we have several papers along from 1849 to 1860, and in 1860 his "Post-Pliocene Fossils of South Carolina." Holmes did not attempt so much to trace the extent of formations or to correlate beds; his work was rather that of a paleontologist and serves as a foundation for the man who would endeavor to establish geological correlation and succession and extent of beds. In addition to the usual molluscan fossils, there were

remains of many vertebrata found, especially on Ashley River, about forty species. Professor Agassiz, who visited the region with Holmes, described it as "the greatest cemetery he ever saw." In a paper before the American Association for the Advancement of Science, March, 1850, Holmes described at some length this very interesting locality. In depressions in the Eocene marls, says he, which are exposed for several miles along the Ashley up stream from a point about a mile below old Ashley Ferry, mingled with detritus and molluscan fossils, were found the remains of many vertebrate animals. They were also found in the bed of loose gravelly sand and among the fragments of Eocene marl which are largely robbed of their lime and have their interstices filled in with blue mud and in places with peat, the whole being somewhat in a bed just above and partly mixed in with the sand. At just what age these beds containing the vertebrate remains were deposited, he did not attempt to say further than that they had been deposited since the Eocene, and that the Miocene and Pliocene were generally thought to be absent from this region, and that then the beds must be post-Pliocene or Recent. In his post-Pliocene text he unhestitatingly pronounces these beds to be post-Pliocene, and enters descriptions and cuts of the vertebrate fossils found in them. In this part of the work Professor Joseph Leidy, of Philadelphia, rendered valuable service. He was greatly interested in the Ashley River vertebrate remains, visited Holmes and made collections for himself. He differed with Holmes in some particulars, regarding some of the forms which Holmes regarded post-Pliocene as recent. He wrote descriptions of the fossil vertebrata, and these make up a considerable part of the volume. Holmes did not attempt to trace the non-fossiliferous Pleistocene back from the coast, but neither did Ruffin nor Toumey. In fact, Toumey says that owing to the blending of the strata it is almost impossible to distinguish the arenaceous beds of the different Tertiary formations. "The sandy beds of the Buhrstone are intermingled with those of the Pliocene, which pass into the superincumbent beds of the post-Pliocene, and the latter are in turn blended with the moving sands of the coast."

From 1856 on through a few years, Mr. O. M. Lieber, State geologist, made his annual reports on the survey of South Carolina. For the most part these reports treat of the Piedmont portion of the State and are largely of an economic nature. He does, however, in the report for 1856 touch upon Pleistocene formations. He, too, had his tilt at the great question of the subsidence of the coast, and

in an article published in the American Journal of Science in 1859, he treats changes along the coast and puts himself on record as a believer that the coast is subsiding.

About 1870 the phosphate industry of the State had grown to such proportions as to make the question of the origin of the phosphoric acid, of the extent of the beds, of the varying richness and probability of continuance a matter of investigation for geologists. Dr. U. C. Shepherd, Prof. N. S. Shaler, and Prof. F. S. Holmes were among the number to turn their attention to these phosphate deposits. The fragments of Eocene (as then considered) marl, worn and robbed of their lime and giving a "naphthous odor" when rubbed together, that Tuomey and Holmes, and perhaps others, had noticed along the Ashley as early as 1850, were found to be rich phosphate. The question as to how they were enriched links them to the Pleistocene, for it is generally thought now that the phosphoric acid has been supplied from the offal and bones of the vertebrate animals whose fossils Holmes claims for the Pleistocene. Be that as it may, Shaler studied the geology of the Carolina coast region, and in his article in the United States Coast Survey, Report of 1870, he contributed something to the knowledge of South Carolina Pleistocene. In general, he observed: That the two or three tiers of islands along the coast from Winyah Bay southward are separated from one another and from the mainland by tide-water creeks that are for the most part parallel to the shore line, and that therefore the stream channels are not the result of glacier scourings, as is the case along the coast of Maine; that the origin of these stream channels, since no sign of aerial erosion could be found, must be attributed to the work of tidal currents before this region was uplifted the last time or just as it was being uplifted; that according to Professor Agassiz, the Florida mole had not been built in early Pleistocene times, and that therefore the Gulf Stream came in much closer to the shore then than now, and its power as a scouring agent was more vigorous; that there is no real subsidence of the coast, the seeming subsidence being due to the land being undermined by the waves and to the decay of considerable thicknesses of vegetable matter, bringing about a settling down of the overlying sands.

There remains of this historic review only to mention briefly the work done in the region within the last quarter of a century, such work being used as a basis for another division of this paper. In 1881 Professor Leidy discussed "Vertebrate Remains, Chiefly from South Carolina." In 1882 we have the report of the Committee on

the Artesian Well of Charleston, which is remarkably full of scientific knowledge, especial pains having been taken to notice everything that came up and from what depth. In 1883 and 1884 the "Agricultural Reports" of the State were made by Major Harry Hammond; they are of not much worth geologically, being almost altogether agricultural. In 1888 "Three Formations of the Atlantic Slope," by W. J. McGee, was published in the American Journal of Science. This treatise does not deal directly with these formations in South Carolina. In 1890 McGee, in his "Appomattox Formation," touched slightly on what he considered the continuation of this formation into the State. In 1891, in his "Lafayette Formation," he gave several pages to South Carolina. In the same year J. A. Holmes, whose knowledge of the geology of the State is extensive, gave an account of the mineralogical, geological and agricultural surveys of the State in the Elisha Mitchell Science Society Journal. In 1892, in the second part of the third volume of the Transactions of the Wagner Free Institute of Science, Dr. Dall discusses the marine Pliocene beds of the Carolinas, telling of the work of C. W. Johnson on the Waccamaw, and giving a list of Pliocene fossils from the Waccamaw beds. In the same year Dr. Dall, with the help of G. D. Harris, prepared an extensive description of the Neocene of North America, Bulletin No. 84 of the United States Geological Survey; in this the South Carolina formations are treated with some degree of fullness. In 1896 N. H. Darton, in "Artesian Well Prospects in the Atlantic Coastal Plain," Bulletin No. 138, U. S. G. S., and in "Notes on Relations of the Coastal Plain Region in South Carolina," Bulletin, Geological Society of America, gave what is still believed, in the main, to be the true order of beds in the parts of the State that he investigated. In 1905 L. C. Glenn, in "Underground Waters of the United States—South Carolina," Water Supply and Irrigation Paper No. 114, U. S. G. S., gives a few pages to the discussion of the succession and extent of the Coastal Plain series of the State.

II. GEOGRAPHICAL DISTRIBUTION OF THE PLEISTOCENE OF THE COASTAL PLAIN.

The Pleistocene formation of the Atlantic coast is generally described as extending from the terminal moraine in north-central New Jersey through Maryland and Virginia and the South Atlantic and Gulf States on to the Mexican border line and beyond. It everywhere unconformably overlies the earlier formations and in places

overlaps upon the crystalline area of the Piedmont Plateau, especially along stream channels cut in these rocks. It is divisible throughout this stretch of country into two general divisions: (1) That just along the present shore line, extending back a few miles only, composed of sands, clays and loams fairly well stratified and containing fossils, in most cases overlaid by recent sands and coarser material. (2) That extending from the old Pleistocene shore line and in some cases, from up the stream channels some distance down to within a few miles of the present shore line, to where it intergrades into the fossiliferous Pleistocene. The beds of this second division, consisting of sand, gravel and (in the northern part) bowlders, mixed with finer sands, clays and loams, are not so well stratified as are the beds of the other division, and contain no marine invertebrate fossils. It is of much greater area than the first division, and is the surface formation throughout much of the Coastal Plain region. In the northern half of this stretch of country, the non-fossiliferous portion of the Pleistocene or the Columbia seems to be capable of a ready division into two or more formations. This is especially true in New Jersey and Maryland, where it has been studied more thoroughly than elsewhere. Also in Virginia divisions have been made. In the southern part, especially in South Carolina, no suitable basis for subdivisions has as yet been found.

Outside of this broad continual mantle of Pleistocene or Columbia sands, there are disconnected areas of it to the north of New Jersey, along the coast of New York and New England and on the neighboring islands, and indeed on up to Labrador and Greenland. It is well to note here that the Pleistocene is generally considered to have been ushered in with the first great advance of the ice-sheet from the North into more southernly latitudes—with the Glacial Epoch, in a word. Therefore, in this northern part of the formation, the deposits consist largely of the product of glacial action; clay, sand and bowlders, arranged in the way peculiar to glacial action or to the influence of glacial action. Of course, where the deposits have been submarine, the material may have been reworked and changed from strictly glacial deposits. The Pleistocene deposits about Lake Champlain and along the St. Lawrence and elsewhere along the coast north of Maine may, in this discussion, be set aside and the tracing begin with Maine and extend only to Florida. This includes the Pleistocene that is closely related to this formation in South Carolina. It seems best to treat the Pleistocene by States.

MAINE.

According to Packard,[1] there are two distinct horizons of the Pleistocene in Maine as is indicated by life-forms. The older is found along the coast at about high-tide mark at the bottom of the bowlder clay. The younger occupies the coast region from the shore line to fifty miles or more inland, and ranging from 25 to 300 feet in altitude. J. D. Dana, in his "Manual of Geology," fourth edition, page 983, makes the statement that the Pleistocene exists along the coast of Maine, and extends back from the shore line some miles at different elevations up to 225 feet. From the places he cites, the Pleistocene localities seem to be in two belts; one just along the shore line, and the other back at a distance of fifty miles almost parallel with the shore line. The following Pleistocene fossils have been reported from these localities: *Leda penula, Leda tenuisulcata, Leda minuta, Yoldia glacilis, Pecten Groenlandicus, Pecten islandicus, Cardium islandicus, Astarte Banksii, Astarte elliptica, Astarte castanea, Thracia Conradi, Macoma fragilis, Macoma sabulosa, Saxicava arctica, Mactra ovalis, Mya truncata, Mya arenaria, Pholas crispata, Natica clausa, Lunatia Groenlandica, Lunatia heros.* The strata containing these shells of undoubted Pleistocene Age are for the most part composed of clay, in which there is a generous intermixture of bowlders.

NEW HAMPSHIRE.

According to Dall and Harris, in Bulletin No. 84, United States Geological Survey, there is in the southeastern part of Portsmouth a deposit of blue plastic clay, containing *Nucula, Macoma* and a few recent forms, which is doubtless of the same age as the Pleistocene just described as occurring on the coast of Maine.

MASSACHUSETTS.

There are several exposures of fossiliferous Pleistocene beds along the coast of Massachusetts and on the neighboring islands. Later in this paper there is given a partial list of Pleistocene fossils found at Sankoty Head on the Island of Nantucket. The strata here consist of clay at the base, of thirty-three feet of sand, gravel and clay con-

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[1] "Results of Observations on the Drift Phenomena of Labrador and the Atlantic Coast Southward" (Am. Jour. Sci., 2d ser., Vol. XLI, pp. 30-32); "Observations on the Glacial Phenomena of Labrador and Maine, etc." (Am. Jour. Sci., 2d ser., Vol. XLIV, pp. 117, 118).

taining fossils, forty-two feet of sand and gravel without fossils, one foot of peat, and at the top of the section six feet of dune sand. The species of shells in the beds, according to Verrill,[1] indicate a warmer climate by 15° F. for the deposition of the lower bed than for that of the upper; 70°-75° F. for the lower and 55°-60° F. for the upper—one a warmer climate than now prevails, the other a colder. On Martha's Vineyard almost all the superficial deposits are of Glacial or Recent age, the pre-Glacial outcropping only at Gay Head and Chilmark Cliffs. On the island of Nanshon, northwest of Martha's Vineyard, almost all the surface formations are of such a nature as to denote glacial action, if not in the deposition at least in the wearing and rearranging of material already deposited during some preceding period. Shaler is disposed to consider "these sands more nearly related to the deposits of the Glacial Age than to those of the preceding series."

RHODE ISLAND AND CONNECTICUT.

Here and there along the shores of these two States, especially of Rhode Island, have been found exposures of the Pleistocene formation, containing characteristic fossils. In the neighborhood of New Haven, on Long Island Sound, the Pleistocene terrace from an elevation of about twenty feet slopes evenly toward the Sound. Not much has been written on the extent of the Pleistocene in these two States.

NEW YORK.

Staten Island, Long Island and Gardiner's Island bear in their surface formations evidences of glacial action. The old terminal moraine extends across Long Island. The sands and gravels of Gardiner's Island, according to Sanderson Smith[2], contain twenty-five species of fossil forms, of which all but two now inhabit the waters South of Cape Cod. They indicate that the climate under which they lived was colder than that which now prevails on the same coast. In all this region from New York to Maine, the Pleistocene deposits are so intermingled with the drift and so covered by it that they have not been worked out so satisfactorily as otherwise might have been the case.

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[1] "On the Post-Pliocene Fossils of Sankoty Head, Nantucket Island" (Am. Jour. Sci., 3d ser., Vol. X, pp. 364-75).

[2] "Notice of a Post-Pliocene Deposit on Gardiner's Island, Suffolk County, New York" (New York Lyceum Nat. Hist., Annals, Vol. VIII, pp. 149-151).

NEW JERSEY.

Beginning with New Jersey south of the terminal moraine, however, there is better opportunity to study the formations of the Pleistocene Age than in the country to the north. This State has been worked and reworked by able geologists. The most thorough work, especially for the Pleistocene, has been done by Professor Salisbury, working through a number of years with one or more assistants. The Pleistocene has been traced and mapped, and described as constituting a large part of the surficial deposits of the State in that portion lying to the east and south of a northeast-southwest line running from near the mouth of the Raritan River on to Trenton on the Delaware, with a few isolated patches lying to the northwest of this. The Pleistocene here has been divided into two or more divisions, the ground for which, in the absence of fossils, has been based upon differences in the physical constituents of the several formations combined with the topographical relations. The Bridgeton formation, earliest Pleistocene, rests unconformably upon the Beacon Hill formation (which is either very late Miocene or else Lafayette or Pliocene) and older formations. The material is heterogeneous, consisting of bowlders, large and small, of gravel, coarse sand and fine, the coarse sand and gravel predominating. The material has evidently been derived by glacial and stream action from the older Beacon Hill, the Miocene, the Triassic, the crystalline schists, and from certain Paleozoic formations varying with the locality. This formation extends in patches across the middle portion of that part of the State occupied surficially by the Pleistocene. The Pensauken, Middle Pleistocene, extends in remnants across the State in northeast-southwest direction in two belts—one along the trough from Raritan Bay to Trenton and Salem, and then down the Delaware River; the other in the eastern part of the State, almost paralleling the shore line and extending back only a few miles from the shore. The Cape May formation, late Pleistocene, covers the border of the State along the Atlantic from Raritan Bay to Cape May; then along Delaware Bay and River to Trenton, everywhere extending back several miles from the shore line, and up stream valleys in some cases twenty-five or thirty miles. It is most abundantly developed in the southern part of the State—in Cape May, Cumberland and Salem counties. The material of the Cape May formation consists of gravel, sand and loam, and indicates, from its slight elevation (forty or fifty feet) and from the absence of bowlders, that it was deposited under less vigorous stream action than were the Pensauken and

Bridgeton. Indeed, it seems that the successive Pleistocene submergences of this State became slighter and the glacial influence less pronounced as the Recent period was approached.

PENNSYLVANIA AND DELAWARE.

The extreme eastern border of Pennsylvania along the Delaware, south of Trenton, has surficial deposits of Pleistocene corresponding to the Pensauken and Cape May of New Jersey, just across the river. Delaware, lying between New Jersey and Pennsylvania on the one hand and Maryland on the other, is largely covered with the Pleistocene. The divisions of the Pleistocene in Maryland correspond to those in New Jersey; and the Delaware Pleistocene, though almost no recent work has been done on it, is undoubtedly capable of being divided in the same way.

MARYLAND.

The Pleistocene in Maryland consists of a mantle of unconsolidated loams, sands and gravels, covering most of the earlier deposits of the lowland and lapping well up on the Piedmont Plateau in places. McGee, Darton, Shattuck and others have worked on the relationships between the different phases of the Pleistocene and earlier formations. The Columbia or Pleistocene has been divided variously by the different workers in the field. One division makes a fluvial and an interfluvial phase, together with a littoral or low-level deposit. The fluvial consists of deltas deposited under water by those streams in whose valleys they now occur when the land stood lower than it does today. It is subject to further division, the lower member being composed of sand, gravel and huge bowlders, the upper of clay and loam. The material as a whole is coarser near the mouths of gorges, where the streams leave the Piedmont Plateau, than in the more remote parts of the deltas. The interfluvial phase possesses no regular stratification, but is an indiscriminate mixture of clay, sand and gravel, water fashioned but not fluvial, which mantles the divides. The low-level deposit, just along the shore and in some cases extending up the rivers, contains in some of its exposures fossils of mollusca and other forms. Another division, that of Darton, separates the Columbia into an earlier and a later Columbia. The Columbia rests unconformably upon the Lafayette or Pliocene. These three formations, the Lafayette and the two members of the Columbia, are found in the upper part of the stream channels which

they occupy in the following order: At the top, Lafayette; then, on a middle terrace, the earlier Columbia, and farther down the later Columbia. This indicates clearly that the successive submergences were slighter and slighter. Along the coast and back from the stream channels these formations are not developed in terraces so plainly, but in a more continued series with an erosion break between the Lafayette and the earlier Columbia.

The latest division of the surficial deposits of the Pleistocene in Maryland is threefold: Sunderland, Wicomico and Talbot. The Sunderland is considerably developed in Prince George's, Charles, St. Mary's and Calvert counties, lying against the Piedmont or lapping around the edges of the Lafayette. The material composing it consists of gravel, sand and loam, containing occasional bowlders. The base of the Sunderland is about 90 feet above tide, and in places reaches 170 feet above tide. The Wicomico consists structurally of material very much like that of the Sunderland, but the proportion of sand and loam is larger. The base of this formation is about forty to fifty feet above tide level in southern Maryland, but higher in altitude to the north. The Talbot formation is a terrace of varying width, lapping around the edges of the Wicomico, attaining a height of thirty to fifty feet. Any sort of material that enters into the composition of the other terraces may be found in the Talbot, but the percentage of loam is greater, and it also contains lenses of greenish-blue clay, in which are embedded plant remains. The Cornfield Harbor clays, carrying remains of marine and brackish-water animals, and also similar deposits five miles south of Cedar Point are referred to the Talbot formation. This is an instance of the grading over of the Columbia sands of the region back from the coast into the littoral or low-level Pleistocene. The base of the Talbot terrace is irregular, lying above tide at some places and below at others, but the top where it borders the sea cliff is usually limited by the forty-five or fifty foot contour. Large areas of Wicomico and Talbot have been mapped on the "western shore" of Maryland, but it is on the "eastern shore" that they attain their most marked development.

The following, according to Shattuck[1], may have been the order and extent of the later Coastal Plain formations in Maryland: Miocene elevation and erosion; subsidence and deposition of Lafayette;

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[1] "The Pleistocene Problem of the Northern Atlantic Coastal Plain" (Am. Geol., Vol. XXVIII, pp. 87-107, 1901).

elevation and extensive erosion; subsidence and deposition of the Sunderland around the edges of the Lafayette; elevation and erosion; subsidence and deposition of the Wicomico terrace about the margin of the Sunderland; elevation and erosion; subsidence and deposition of the Talbot about the margin of the Wicomico; elevation and partial erosion of the Talbot; subsidence and deposition of the Recent terrace about the edges of the Talbot.

This division of the Pleistocene in Maryland has been entered into rather more fully than may seem necessary for the immediate purpose, but is put here because of the fact that it is to be referred to in treating the South Carolina Pleistocene. The same may be said for the discussion of the surface formations of New Jersey.

In Maryland it seems that the later Columbia comprises both the Talbot and the Wicomico, while the earlier Columbia finds its equivalent in the Sunderland. The indications are that the successive subsidences were greater in the northern part of the formation than in the southern. The materials deposited contain larger bowlders in the northern than in the southern part. The successive submergences seem to have been less as the Recent period was approached. This conclusion fits in well with the observations made in New Jersey.

VIRGINIA.

The division of the Pleistocene or Columbia into fluvial and interfluvial phases in this State is very similar to the same division in Maryland, and need not be given again in detail. However, the indications are that the successive Pleistocene submergences were not so deep as they were farther north. The interfluvial phase is beginning to be the prominent one, and farther south the fluvial phase is almost lost sight of altogether, and the interfluvial is the all-important one. The material here, though in the main the same as that in Maryland, contains relatively much smaller bowlders in the basal member, and farther south the bowlders disappear. As yet no fossiliferous Pleistocene beds have been reported from Virginia, but we are not to conclude that there are none along the Virginia coast. The supposition is that they are there, either unexposed or exposed in some little-frequented localities. The Columbia here, as elsewhere along the middle Atlantic coast, extends well inland to the inner edge of the Coastal Plain region, and together with the Lafayette is almost everywhere the surficial formation. Erosion has in places carried it away, and left the Pliocene or Miocene or other older formation exposed. It is everywhere a mere superficial capping, varying in

thickness from ten to thirty feet. Virginia seems to be the region of change for this formation. In the region to the west and north of Washington, the earlier Columbia is at high altitudes, and the later lies on the low terraces in the deeper portions of the depressions, but to the east and south the later Columbia lies in regular succession on the earlier. As we go farther south from Virginia, the later Columbia advances more upon the earlier, and in South Carolina, where it is almost impossible to make any division at all, perhaps it is that the later has entirely overlapped the earlier.

NORTH CAROLINA.

In this State the interfluvial phase of the Columbia has almost eclipsed the fluvial in extent and in importance. The Pleistocene formation here is so closely similar in occurrence and in composition to the same formation in South Carolina that it need not be spoken of at length. About 1840 Conrad wrote a description of a Pleistocene locality on Neuse River, and gave a list of the fossils found there[1], thirty-four in number. But upon further investigation this locality has been classed as Pliocene within late years. However, there are some fossiliferous Pleistocene beds along the coast of North Carolina. As in South Carolina, these beds are confined to a belt along the shore extending inland only a few miles.

SOUTH CAROLINA.

Inasmuch as a separate discussion of the Pleistocene of this State is to be given in this paper, nothing further need be said concerning it here.

GEORGIA.

Very little has been done upon the geology of the Coastal Plain of this State. But Couper and McCallie have given brief descriptions of the region, and McGee, in "Lafayette Formation," gives a few pages to Georgia. The Coastal Plain extends over all that part of Georgia lying south of a line running from Augusta westward across the State by Columbus and Macon. Here, as elsewhere along the margin of the region, the different formations advance in varying degree. The Pleistocene sometimes comes so far inland as to rest upon the Piedmont crystallines, and at other places upon the Potomac,

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[1] "Observations on a Portion of the Atlantic Tertiary Region, etc." (National Inst. Proc., Vol. I, pp. 171-94).

Cretaceous, Eocene, Miocene or Pliocene. There is here that alternation of "sand hills" and "red hills" which is characteristic of North and South Carolina in their central areas. But farther toward the sea the Columbia or Pleistocene is the surface formation completely concealing the Lafayette or Pliocene beneath. The formation varies in thickness from a few inches to several feet. In the belt just along the coast, Pleistocene fossils have been found.

FLORIDA.

The greater part of Florida is covered superficially with a thin capping of white sand, just beneath which is yellow sand. The age of these sands has not yet been fully determined. Florida is unusually rich in marine Pleistocene deposits. To use the words of Dall and Harris concerning these marine deposits: "There are multitudes of such localities where these beds are visible, mostly at elevations not very far from present water-level, and indicating a small elevation, with possibly a smaller subsequent depression, since they were deposited on the western side of the peninsula; while on the east there has been a slow, somewhat intermittent elevation, which has amounted in the total to not less than twenty feet above the present sea level in the cases where it is lowest, and possibly as much more in some localities. Without definite proof of the fact, it seems as if there had been a tilting of the peninsula on its north and south axis in Pleistocene times." These Pleistocene localities are especially plentiful along the western side of the peninsula, in one place overlying the Pliocene and in another the Miocene. Elsewhere in this paper may be found a list of the Florida Pleistocene fossils.

III. GEOGRAPHIC AND STRATIGRAPHIC RELATIONS OF THE PLEISTOCENE IN SOUTH CAROLINA.

The order of formations in the Coastal Plain of South Carolina is, as can be best determined, as follows:

Columbia	Pleistocene
Lafayette	Pliocene
Miocene	Miocene
Eocene	Eocene
Marine Cretaceous	Cretaceous
Potomac	Cretaceous

The Potomac outcrops just along the western border of the Coastal

Plain in a belt four or five miles wide, sometimes swelling to a width of ten miles, extending from Augusta through Aiken, south of Lexington, through Columbia and on into North Carolina, through Camden and Cheraw. The lower strata of the formation differ markedly from the upper; they consist of coarse sands mainly with pebbles, sometimes consolidated to a soft sandstone toward the south. The upper beds are composed of finer sands and clays in the main. However, there seems to be an intergrading of these two series of strata, clays occurring in the lower and cross-bedded standstones in the upper in places. The Potomac, outcropping here and overlying the Piedmont crystallines, extends on out beneath the later formations, and has been reached and bored through or into, in boring artesian wells at Florence, Darlington, Marion, Charleston and other places. The beds in these places show a combined thickness of 400 feet or more. Its slope toward the sea is greater than the surface slope today. It is highly probable that there is a marine phase of the Potomac into which the true Potomac, as just described, intergrades. But the fossils reported by Toumey, as occurring in these beds at the outcrop, are perhaps nothing more than the impressions of mica plates so curved as to appear very much like the impressions of shells or rather fragments of shells.

The Marine Cretaceous unconformably overlies the Potomac in the northeastern part of the State. The materials are marls, sands, and clays with characteristic fossils. The formation seems to thin out before reaching the Santee and Wateree toward the south, and is in most places overlaid by some one of the Tertiary formations. Along the Waccamaw, it is plainly exposed in many places and is overlaid by the Pliocene. On the Peedee and some of its tributaries the Cretaceous is also exposed, and in some places overlaid by the Pliocene and in others by the Miocene. There is probably an exposure or two on Black River, a few miles below Kingstree. The formation, which is near the surface in Horry, Marion, Darlington, Florence, Williamsburg, and Georgetown counties, after seeming to pinch out just east of the Wateree-Santee line, thickens enormously toward the south, so that at Charleston it occupies the greater part of the depth between 450 and 1,950 feet in the artesian wells. But some of this thickness at Charleston and in the southern part of the State may be the marine phase of the Potomac. The distinction the writer would make between marine Cretaceous and the marine phase of the Potomac is simply one in point of time of deposition—the marine Cretaceous being put down upon the Potomac after an

erosion interval, the marine phase of the Potomac being put down at the same time with the true Potomac. To just which one of these two formations the beds at Charleston belong, is a question which is not yet fully determined. Darton seems to consider the greater part of this thickness as belonging to the marine phase of the Potomac; but the fossils from it have an appearance very similar to that of the fossils of the marine Cretaceous of New Jersey, and the probability is strong that these beds at Charleston, to a considerable depth, are marine Cretaceous resting upon the Potomac.

South and west of the Santee, the Potomac is overlaid by the Eocene, which also extends northward overlying the marine Cretaceous and becoming thinner and thinner as it stretches northward until it exists only in widely scattered patches on the irregular surface of the Cretaceous marl and gives out altogether before reaching the Waccamaw. At Charleston and thereabout, the Eocene rests upon the marine Cretaceous. In the western part of the Eocene formation in the State, where it outcrops along the line from Aiken to within a few miles of Columbia, the lowest beds are composed of buhrstone and argillaceous beds. This Buhrstone formation, according to Darton,[1] appears to lose its characteristics in the extreme eastern part of the State and becomes a marl. According to the same writer, the thickness of the Eocene members at Charleston is about 370 feet, and are supposed to extend upward to about 60 feet from the surface. Now, elsewhere in this chapter, it is pointed out that the Pliocene has been reported from a depth of 65 feet at Charleston. If this latter statement be true, then the Eocene must be somewhat farther down still—maybe very little farther. Besides the Buhrstone the Eocene beds consist of marls of various kinds, which have been put into two classes by Toumey and others—viz., the Santee beds, which are light colored, and the Ashley and Cooper beds, which are darker in color.

What small, thin patches of Miocene have been left after erosion are in the northeastern part of the State, in Florence, Sumter, Darlington and Marion counties. It occupies depressions in either the Eocene or the marine Cretaceous. The beds are rarely more than thirty feet in thickness, and are generally much thinner. They consist of sands and marls and contain many species of molluscan fossils. Other small areas of it have been found in the southern part

[1] "Notes on the Relations of Lower Members of the Coastal Plain Series in South Carolina" (Geol. Soc. Amer., Bull., Vol. VII, pp. 512-18, 1896).

of the State, notably on Goose Creek and on the Ashley. The geographical situation of these remnants of beds indicates that the Miocene formation was deposited continuously over the lower part of the Coastal Plain area of the State, but has been so extensively eroded as to leave only these fragments here and there.

The Pliocene in South Carolina may be looked upon as divided into a fossiliferous and a non-fossiliferous member. The latter is called Lafayette, but may prove to be of the same age as the fossiliferous Pliocene. The fossiliferous beds are well cut into by the Waccamaw River, and afford many species of fossils, and are seen to contain an occasional nodule of phosphatic material. The presence here of phosphate in well-determined Pliocene deposits, together with the fact that the Pliocene beds of Florida are highly phosphorated, lead us also to consider the phosphate beds in the region about Charleston to be either Pliocene in age or else to have been phosphorated during this period. These facts, combined with the occurrence of Pliocene fossils from a depth of sixty-five feet in the artesian wells of Charleston, indicate that the fossiliferous Pliocene may underlie the surface formation of a large part of the coast of the State. The color of the sand and clay in which the fossils on the Waccamaw are embedded, is yellow and in marked contrast to the gray sands above. This furnishes a connecting link between the fossiliferous Pliocene and the Lafayette farther inland, which is everywhere seen to consist of "orange-colored" sands and clays. Future detailed work may reveal an intergrading of the two members. It at any rate seems perfectly safe, from its occurrence elsewhere, to regard the Lafayette as Pliocene. According to McGee[1], the Lafayette formation extends across the State in a broad belt at an elevation varying from 25 to 650 feet above tide level. In the western part of its extent the Lafayette rests unconformably upon the Piedmont crystallines in some instances, and again upon the Potomac. Toward the east it rests unconformably upon the Miocene, Eocene or Marine Cretaceous. It varies in thickness from thirty to eighty feet. Though "orange colored" for the most part, yet there are marked variations in the color of the sands, clays and loams which compose the formation. Sometimes the color is a chocolate brown, at other times a brighter red than the usual orange. The Pliocene is everywhere, except, perhaps, on its western margin, unconformably overlaid by the Pleistocene; or, differently expressed, the Lafayette is everywhere unconformably

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[1] "Three Formations of the Middle Atlantic Slope" (Am. Jour. Sci., 3d ser., Vol. XL, 1890).

overlaid by the Columbia. Where erosion has carried away the gray or whitish-colored Columbia sands and the alternating orange-colored sands are exposed, the difference is quite marked and the contrast rather pleasing than otherwise.

The fossiliferous Pleistocene, as stated elsewhere in this paper, is exposed in numerous places along the entire coast line of the State, where streams have cut down and carried away the overlying material Nowhere do these exposures occur farther inland than ten miles from the present shore line. Everywhere the bed is not far above or far below tide level, though at one place, Laurel Bluff, it occurs, according to Tuomey, at an elevation of eight feet above tide, and at Charleston it lies several feet below tide. The following descriptions of localities, together with sections where they could be obtained, will serve to show this. In making these descriptions, recourse is had to the literature on the subject, especially where the country has been so changed by the forces of nature and by man's activities—in phosphate mining and otherwise—as to almost, if not quite, destroy these beds of shells once so well exposed.

I. Price's Creek (White Point Creek), Horry County.

The exposure here seems to have been a bed of loose sand and shells, not deeply covered by overlying sands, as is the case in many other localities. The bed was about six feet thick and was elevated above tide about five feet. Among the shells found were *Venus mercenaria, Ostrea Virginica, Scapharca incongrua, Arca Noae* and a species of *Pectunculus.*

[I use the past tense here because of the fact that this bed could not be located last summer, as explained in the introduction to this paper.]

II. Laurel, Georgetown County, northeastern corner.

A section here of the perpendicular bluff of the Waccamaw gives:

Yellowish, light-colored sand	20 feet
Blue mud	6 inches to 1 foot
Fossiliferous bed, sand and broken shells, containing *Arca, Mactra, Rangia,* etc	8 feet

The top of the bed is eight feet above tide. This is possibly a Pliocene bed, as some have claimed; but the fact that all the fossils listed from it have been found elsewhere in the Pleistocene, and also especially that *Donax variabilis,* one of the species found, has not been found as yet earlier than the Pleistocene, justifies one in considering the bed Pleistocene rather than Pliocene.

III. Winyah Canal, Georgetown County, southern part.

Here, in excavating the canal connecting Winyah Bay with the north run of the Santee, Pleistocene fossils were exposed. This indicates that the whole country thereabouts is underlaid at a slight depth beneath the surface by this formation.

IV. Wambraw Creek (?), Charleston County, northern part.

To quote directly from Tuomey: "In Christ Church Parish, Charleston District, there are several exposures where this bed comes so near the surface as to be within reach of the plough. The marl is sufficiently calcareous as to be of great economic value. In one instance I found a bed of calcareous mud, such as is formed by the disintegration of corals." As well as can be learned, this locality is on Wambraw Creek, or not far from it.

V. Goose Creek, north of Charleston.

The section here, according to Holmes, is:

Yellow sand	12 feet
Blue mud	2 feet
Ferruginous sand, containing bones, etc	3 inches
Yellow sand	3 feet
Pliocene marl, resting on Eocene white marl	12 feet

The fossil bones are in a good state of preservation, especially in the blue mud. More will be said of these deposits of vertebrate fossils in describing the next locality.

VI. Ashley River.

This locality, famous for the beds of vertebrate fossils which Holmes, after a careful study for a number of years, considered Pleistocene, and which are still considered Pleistocene by most geologists, furnishes about thirty-five or forty species of vetebrate fossils. A section here gives something like this:

Yellow sands with bands of clay	4 feet
Blue mud just above the Miocene marls	1 foot to more.

In some places there is a varying thickness of sand or of sand and clay between the blue mud and the Miocene marls. The fossil bones which are found in these strata are often in a good state of preservation, especially those in the blue mud. This locality and that on Goose Creek were especially interesting to the geologists of thirty-five or forty years ago, when numerous vertebrate fossils could be picked up; but now that they have been despoiled in working the phosphate deposits, they have lost some of the interest that they once

had. These sections have been given more as a matter of historic interest than anything else.

VII. Bee's Ferry, Ashley River.

Here a section shows:

Fine, loose sands	15 to 20 feet
Fossiliferous bed, sands and shells, well preserved	3 feet
Fine laminated clay, resting on blue mud with layers of sand between laminea, containing *Mactra*	6 inches

The top of the fossiliferous strata is about at high-water mark. This exposure is about 200 yards long, and from it Tuomey collected twenty-six species common to the Pleistocene elsewhere in the State.

VIII. Charleston.

A section from the wells in the city shows the following order of strata:

Loose sand, below which water is found	5 to 6 feet
Quick sand and clay, with occasional remains of trees	9 feet
Sand and small shells	1 foot
Gravel and oyster shells	2 feet
Fine, close clay and young oyster shells	3 feet
Pluff clay, with scales of mica	20 feet

Continuing this from the report of the special committee on the artesian well, Charleston, we have, after a break:

Pliocene deposit with *Tellina, Arca,* etc.	from 65 to 100 feet
Tertiary, *Venus, Tellina,* phosphate nodules	from 80 to 100 feet
Tertiary, phosphate nodules, oyster shell breccia	from 350 to 430 feet
Cretaceous fossils, varying with depth	from 600 to 1,955 feet

IX. Stono River.

The section here, according to Dr. Glenn, is:

Sands, mostly loose, light-colored near surface from vegetable matter, but in middle and lower parts varying from light cream color to red	8 to 14 feet
Pleistocene fossils in white or light gray sand with little mud and with some loose nodules of phosphate rock	3 to 4 feet
Nodular phosphate rock overlying Tertiary marls. Shells well preserved in the beds, which were being removed to get at the phosphate rock beneath	0 to 4 feet

X. Young Island, Wadmalaw Sound.

A section of the bluff in the lower part of which lies the fossil bed is:

Loose, yellowish, light-colored sands	10 to 15 feet
Ferruginous sand with casts of shells, breaking in fairly good lumps	2 feet
Red or brownish clay	2 feet
Fossiliferous bed, sand of grayish color with little mud, with comminuted shells, fossils in fine preservation	3 to 4 feet

The part of the bluff above the fossil-bearing stratum is almost perpendicular, but the fossil bed slopes gently beneath the tide. The tide rises to the level of the top of the bed of fossils. If observations or collections are to be made, they must be made when the tide is low. Many of the shells here, such as *Barnea costata* and *Labiosa canaliculata*, are found in pretty much the same position they occupied in life, having both valves entire and in correct position. The shells are remarkably well preserved, having a bright, fresh appearance, oftentimes retaining the polish and color they had the day they were deposited.

XI. Doctor's Swamp.

Here the fossil bed, which is of the usual thickness, three or four feet, is overlaid by a kind of marshy soil surcapped by sand. The extent of the exposure is considerable, being perhaps five miles in length.

XII. Lady's Island and other points around Beaufort.

A section in that neighborhood, which is roughly characteristic of the fossiliferous Pleistocene in that whole region, is about as follows, according to Ruffin:

Loose beach sand	8 to 10 feet to more
Marl similar to the common blue Miocene marl of Virginia, but containing Pleistocene fossils	3 to 4 feet.

The fossiliferous Pleistocene, as is seen from the situation of the localities just described, extends along the coast of the State from northern Horry to southern Beaufort. It is composed here of sand, clay and mud, with by far the greater percentage of sand in most localities where examined. The fossil-bearing strata themselves are rarely ever more than four feet in thickness, though the whole Pleistocene formation may, in many places along the coast, be forty or fifty to sixty feet in thickness.

In Horry and Georgetown counties, it overlies the Pliocene, as has been fully determined; and if the report of the Special Committee on the artesian well at Charleston is to be relied upon, the Pliocene also underlies the Pleistocene there. From a depth of sixty-five feet were reported shells of the Pliocene Age. It is well known that, following the Pliocene submergence and deposition, there was a period of elevation and extensive erosion. Now, it is altogether possible, entirely probable, that the Pliocene was entirely eroded and carried away in places, but it is hardly probable that it would be altogether removed from so extensive a stretch of country as that from southern Georgetown to the Georgia line, as some have supposed, as may be assumed from the statement made: "They [the Pleistocene strata] rest in Horry and Georgetown on the Pliocene and for the remainder of the coast on the Eocene." In many places, no doubt, and over extensive areas, they do rest upon the Eocene; but the fact, if it be a fact, that the Pliocene exists at a depth beneath Charleston that corresponds to the thickness of the Pleistocene is an indication that the Pliocene underlies the Pleistocene not only in Horry and Georgetown, but all along the coast where it has not been entirely removed by erosion. For if the Pliocene exists beneath Charleston, as has been determined by materials brought up from wells where a record has been kept, in all probability it also underlies the Pleistocene in many other localities. This supposition, and in the nature of the case, it can be no more than a supposition, can be held to until records from wells either confirm or contradict it. The likelihood is that it will be confirmed; for we have some additional proof that there are remnants of other formations between the Eocene and the Pleistocene from Dr. Dall's examination of some fossils found in the "land phosphate" of Ashley River, thought to belong to the Eocene by Holmes and others. Dall has decided, after carefully examining the fossils found in lumps of the "land phosphate" which were picked up on Block Island from the wrecked cargo of a vessel laden with that commodity, that these phosphatized nodules are not of Eocene Age, as generally supposed, but of Miocene Age, nearly related to the Chesapeake Miocene. He found about twenty species of fossils in these nodules of phosphate picked up at Block Island, not one of which was found to be Eocene, but all were well-known later or upper Miocene shells. Hence his conclusion that the phosphatized nodules were of a later formation than the Eocene; indeed, of the upper Miocene, corresponding to the Chesapeake Miocene, as has just been mentioned. He adds that the phosphatizing took place after the formation of the beds, possibly in

Pliocene times, as is the case of the phosphate beds of Peace River, Florida. Again Holmes, in his description of the Goose Creek locality, makes the assertion that the Pleistocene rests upon the Pliocene, which in turn rests upon the Eocene. This, so far as is known to the writer, has not been shown to be false. All in all, then, there seems to be sufficient evidence to warrant the statement that between the Pleistocene and Eocene south of Georgetown, all along the coast, there are intervening beds of Pliocene or Miocene, where these latter beds have not been carried away altogether by erosion, which has doubtless been the case over considerable areas here and there, where stream, wave, current or tide activity has been especially vigorous. This is about what should be expected under normal conditions.

The non-fossiliferous portion of the Pleistocene (and the writer considers this the same as the Columbia of McGee), which includes by far the greater amount of the surficial formation of the Coastal Plain of the State, grades everywhere so gradually and uninterruptedly into the fossiliferous, both in kind and arrangement of materials, except the fossils of course, that it is impossible to draw any distinct line between the two. This has usually been called Columbia from its typical development in the District of Columbia. It has not been found capable of subdivision into fluvial and interfluvial members here, as has been the case in Virginia and farther North. Neither does there exist a basis for such a division as that in Maryland into Sunderland, Wicomico and Talbot, nor as that in New Jersey into Bridgeton, Pensauken and Cape May. In New Jersey these divisions respectfully represent early, middle and late Pleistocene; so likewise do the divisions in Maryland represent the earlier and later Pleistocene—the Sunderland and Wicomico being considered two divisions of the earlier Columbia (or Pleistocene), and the Talbot the later. Doubtless if there were two or more distinct submergences during Pleistocene times in New Jersey and Maryland, there were also in South Carolina; but here there are no terraced rivers or shore lines to show this, and the sands and other materials are so nearly alike as to be indistinguishable. It may be that the Talbot in Maryland corresponds to the fossiliferous portion of the Pleistocene in South Carolina, since to it (the Talbot) have been attributed the fossiliferous beds at Cornfield Harbor and Wailes' Bluff. The supposition is that the successive Pleistocene submergences in South Carolina, though on the whole less marked than those farther north, yet had their relative depths somewhat reversed. That which took place in Virginia, the advance of the interfluvial over the fluvial phase, may

have been so intensified here as to bring about a complete overlapping and obscuring of the fluvial by the interfluvial, or of the "high level" by the "low level," as denoted in Maryland. The sands are for the most part loose, unconsolidated and to distinguish between successive depositions, without the aid of such phenomena as terraces or bowlders and other things which help in the interpreting of conditions farther north, is almost an impossibility at the present stage of investigation into the problem.

As to the areal distribution of the Pleistocene in the State, it may in a word be said to be the surficial formation over the entire Coastal Plain of the State. According to J. A. Holmes[1], the Coastal Plain region of the State is covered almost everywhere with a mantle of loose material—loam, clay and sand, the latter predominating. This covering of sand, extending from the shore back to the inner margin of the Coastal Plain and in places overlapping on the crystalline rocks of the Piedmont Plateau, attains an elevation of 400 to 600 feet, and belongs either to the Lafayette or to the Columbia formation. After briefly describing the occurrences of the Cretaceous, the Eocene and the Lafayette, Holmes says of the Columbia: "Spread out over this deeply and irregularly eroded surface, resting in places on the Lafayette or the Eocene or the Cretaceous, or where all these have been removed, even on the crystalline rocks, lies the mantle of sand and loam known as Columbia." He further says: The topography of this inner margin of the Coastal Plain is as old as the post-Cretaceous and post-Eocene erosion intervals. The valleys and stream channels formed then were nearly filled during the Lafayette deposition, but were opened up again practically along the same lines during the post-Lafayette erosion period. The Columbia deposition mantled these hills and valleys with a slight covering only, and erosion since that time has made but little change in the general topography of the country in this marginal section of the Coastal Plain. Farther toward the sea the sand becomes finer and has more loam intermixed with it. Just along the present shore line and back a short distance the Pleistocene is overlaid by the Recent sands, which are coarser. It may be well to add that the very slight deposition formed during the Pleistocene submergence has been in places eroded from the hills and has left the orange-colored sands of the Lafayette exposed. This intermixture of the two formations has given the "sand hills" and "red hills" of the State. In studying the Pleistocene

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[1] "Geology of the Sandhill Country of the Carolinas" (Geol. Soc. Amer., Bull., Vol. V, pp. 33-35, 1894).

sands, one sees very little or no difference in the material along the streams and that on the divides between the streams. Furthermore, there are no pebbles of such size as to warrant the name "bowlder." The largest water-worn fragments are less than a foot in diameter. This, together with the fact noted by Shaler[1], that the creeks along the Coastal margin are more often parallel with the coast line than perpendicular to it, and, therefore, could not have been the result of glacier scourings as in Maine, justify the assertion that glacial influence did not extend in any marked degree so far south as to South Carolina; indeed, it may be said that glacial influence here was almost if not quite imperceptible.

IV. TABLES OF SOUTH CAROLINA PLEISTOCENE FOSSILS, WITH DATA TO ATTEMPT AN INTERPRETATION OF ENVIRONMENTAL CONDITIONS UNDER WHICH SUCH FOSSILS LIVED.

1. Explanation of Tables.

These tables have been made to include, as nearly as possible, all Pleistocene molluscan fossils from South Carolina. Not much attention has been paid to vertebrate fossils of this age in the State, though such have been found on Ashley River in great abundance and elsewhere in some quantity. This is perhaps the largest list of Pleistocene mollusca that has up to this time been published from the State, including about 180 species, and representing about 110 genera or genera and subgenera combined. Much time and labor has been spent in ascertaining the various facts regarding each species; and, however far astray the writer may go in drawing conclusions from his tables, he feels confident that the tables represent the facts in the case so far as they can at present be ascertained.

In regard to the tables, first, after the name of the species comes the column to show whether or not it is in our own Vanderbilt University Collection; if it is the letter V is found opposite its name. Next are the columns to show the localities in the State where each species has been found. Young Island (Simmons Bluff in the literature) is the most noted locality, though the Stono River beds afford almost as many species. The localities have been arranged in accord-

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[1] "On the Phosphate Beds of South Carolina" (U. S. Coast Surv., Report for 1870, pp. 182-89, Washington, 1870).

ance with the number of species found, as nearly as may be. The fossils listed from Charleston come mainly from the artesian-well borings. The last column of this series contains space for the listing of fossils from localities where only a few species have been found, and is headed simply "Other Places." After this are columns to show whether or not the different species lived in other geologic ages preceding the Pleistocene and what ages, also whether or not they are still living. In this last particular a blank opposite a name does not necessarily mean that the species is extinct; it means simply that, so far as known, the species is not still living. In these columns and in the preceding the cross mark (X) indicates that the species is found in that locality or in that age. In the first column for geologic ages, "Pre-Miocene," the following initial letters are used: E for Eocene; O for Oligocene; C for Cretaceous. Then comes a column to show the relative abundance or scarcity of each species as a Pleistocene fossil, so far as this has been learned. In this column the following initial letters are employed: VR for very rare; R for rare; U for uncommon; NU for not uncommon; C for common; FA for fairly abundant; A for abundant; VA for very abundant. These terms are intended to show a gradual rise in point of numbers from *very rare,* where only one or two or three individuals of the species have been found in a considerable amount of material gathered from any one locality, on up to *very abundant,* where almost a sixth or fifth, sometimes more, of the material may be of a single species.

Then are given, in appropriate columns, items concerning the environmental conditions of such Pleistocene species as are still living. First, a column giving the depth range; in this, following Dall in *Bulletin No. 37 of the United States National Museum,* when no figures are given, it is usually to be understood that the depth is shallow. The figures are given in fathoms, and written with the less depth first; then a dash (-), and the greater depth; for example, 3-24, means ranging in depth from 3 fathoms to 24 fathoms. These depth ranges cannot be relied upon without reserve for any one particular beach or limited locality, for they apply to each species throughout its entire geographical range. As is well known, a species living in Massachusetts Bay, say, at a depth of 6-8 fathoms would, on migrating southward, seek ever-increasing depths in order to find waters as cold as it had been accustomed to. In the second column is given the kind of shore or bottom which the species prefers, whether muddy, sandy, gravelly, shelly, rocky or what not. Where a species

seems to live almost equally as well on one kind of shore or bottom as on another, effort will be made to put its habitats in order of preference. In case the species prefers brackish water, this will also be recorded in this column. The third and fourth columns of these environmental items show the extreme northern and extreme southern geographical ranges of the different species.

In the tables there will occasionally be found the name of a species and not very much additional information concerning it, perhaps only where it has been found as a fossil. This has come about by taking Holmes' list to make this list as full as possible. Occasionally a species, mentioned and described by Holmes, has not been found described anywhere else in the literature accessible, and consequently the columns are left blank opposite such species. This is true of five of the six species of *Fusus* that he gives; true, also, of *Columbella ornata* and *Volva acicularis.* Just after the main tables are found lists of Pleistocene fossils from localities in other States. These lists have been placed here for convenience in ready comparison.

In addition to the facts obtained at first hand, the following publications were used in making out these tables:

"Manuel de Conchyliologie et de Paléontologie Conchyliologique." Dr. Paul Fisher, Paris, 1887.

"Einleitung in die Geologie als Historiche Wissenschaft." Johannes Walther, Jena, 1893.

"Geological Biology." H. S. Williams, New York, 1895.

"Report upon the Invertebrate Animals of Vineyard Sound and Adjacent Waters." A. E. Verrill and S. I. Smith, Washington, 1874.

"Report on the Invertebrata of Massachusetts." A. A. Gould, Edited by W. G. Binney, Boston, 1870.

"Structural and Systematic Conchology." George W. Tryon, Jr., Philadelphia, 1882-1884.

"A Preliminary Catalogue of the Shell-bearing Marine Mollusks and Brachiopods of the Southeastern Coast of the United States." W. H. Dall, Bulletin No. 37, U. S. Nat. Museum, 1889.

"American Conchology or Description of the Shells of North America." Thomas Say, New Harmony, Ind., 1830.

Dr. W. H. Dall's work in the Transactions of the Wagner Free Institute of Sciences, Parts 1-6, Vol. III, Philadelphia, 1890-1903.

Republication of Conrad's "Fossil Shells of the Medial Tertiary of the United States," with an Introduction by W. H. Dall. Wagner Free Institute of Sciences, 1893.

Republication of Conrad's "Fossil Shells of the Tertiary Formations of North America." G. D. Harris, Washington, 1893.

"Three Cruises of the *Blake*." Alexander Aggassiz, Boston, 1888.

"Natural History of New York, Part V, Mollusca." J. E. DeKay, Albany, 1843.

"Report of the North Carolina Geological Survey." Ebenezer Emmons, Raleigh, 1858.

"Report on the Survey of South Carolina." E. Ruffin, Columbia, 1842.

"Geological Survey of South Carolina." M. Tuomey, Columbia, 1848.

"Pleistocene Fossils of South Carolina." F. S. Holmes, Charleston, 1860.

"Post-Pliocene Deposits of Sankoty Head." Fred. J. H. Merrill, N. Y. Acad. Sci., Trans., 1895-1896.

"Observations on a Portion of the Atlantic Tertiary Region, etc." T. A. Conrad, Nat. Inst., Proc., Vol. I, pp 171-194, 1842.

"A Conchological Manual." G. B. Sowerby, Jr., London, 1846.

"Marine Invertebrata of Grand Monan, etc." Wm. Stimpson, Washington, 1853.

Various Papers by W. H. Dall, in the Proceedings of the United States Nat. Museum.

2. The Tables.

	SPECIES.	In Vanderbilt University Museum.	South Carolina Pleistocene Localities.								Other Ages than Pleistocene.			
			Young Island.	Stono River.	Abapoola Creek.	Doctors Swamp.	Cainhoy.	Wando River.	Charleston.	Other Places.	Pre-Miocene.	Miocene.	Pliocene.	Recent.
	Mollusca Pelecypoda.													
1	Nucula proxima Say..................	V	X									X	X	X
2	Leda acuta Conrad..................	V	X	X							O	X	X	X
3	Yoldia limatula Say..................		X							X				X
4	Glycymeris Americana Defrance......		X									X	X	X
5	Glycymeris pectinata Gmelin.........	V		X					X	X		X	X	X
6	Arca Noae Linné.....................									X			X	X
7	Arca pexata Say......................	V	X											
8	Arca ponderosa Say..................	V	X	X					X					X
9	Barbatia Adamsii Smith...............	V		X										X
10	Scapharca incongrua Say............	V	X	X					X					X
11	Scapharca campechensis Dillwyn......	V	X	X					X					X
12	Scapharca lienosa Say...............		X											X
13	Scapharca transversa Say............	V	X	X										X
14	Pteria colymbus Bolten..............	V	X	X	X	X							K	X
15	Atrina rigida Dillwyn................	V	X	X	X									X
16	Atrina serrata Sowerby..............		X		X								X	X
17	Ostrea virginica Gmelin..............	V	X	X								X	X	X
18	Pecten exasperatus Sowerby..........									X				X
19	Pecten gibbus Linné..................	V	X									X	X	X
20	Plicatula gibbosa Lamarck...........	V	X											X
21	Lima scabra Born.....................									X			X	X
22	Anomia simplex Orbigny.............	V	X	X	X							X	X	X
23	Mytilus edulis Linné..................									X			X	X
24	Mytilus exustis Linné................		X										X	X
25	Modiolus modiolus Linné.............	V	X	X										X
26	Modiolaria lateralis Say..............		X										X	X
27	Pandora triliniata Say...............	V	X									X	X	X
28	Crassatellites lunulatus Conrad.......	V	X	X								X	X	X
29	Cyrene caroliniana Bosc..............		X			X								X
30	Cardita floridana Conrad.............		X										X	X
31	Venericardia tridentata Say..........	V	X									X	X	X
32	Chama congregata Conrad............	V		X								X		X
33	Echinochama arcinella Linné.........		X										X	X
34	Phacoides amiantus Dall.............	V	X	X	X									X
35	Phacoides crenulátus Conrad.........				X									X
36	Phacoides radians Conrad............	V	X									X	X	X
37	Phacoides multilineatus Tuom'y&Hms	V	X	X									X	X
38	Phacoides trisculcatus Conrad........	V	X									X	X	X
39	Divaricella quadrisulcata Orbigny....	V	X	X								X		X
40	Diplodanta soror C. B. Adams........	V	X	X										X
41	Diplodanta punctata Say............									X				X
42	Diplodanta semiaspera Philippi.......	V		X										X
43	Cardium robustum Solander..........	V	X	X								X	X	X
44	Cardium muricatum Linné...........	V	X	X										X
45	Cardium isocardia Conrad...........		X		X					X		X	X	X
46	Cardium serratum Linné.............				X						O	X	X	X
47	Cardium Mortoni Conrad.............		X									X	X	X
48	Sportella protexta Conrad...........	V	X	X								X	X	X
49	Sportella constricta Conrad (?)......	V	X									X	X	X
50	Aligena elevata Stimpson............	V	X											X
51	Anisodanta carolina Dall............		X						X			X		X
52	Bornia Mazyckii Dall (?)............									X			X	
53	Macrocallistra nimbosa Solander......		X										X	X
54	Dosinia discus Reeve................	V	X										X	X
55	Chione cancellata Linné.............	V	X	X									X	X
56	Chione cribraria Conrad.............		X		X					X		X		X
57	Chione grus Holmes..................	V	X	X								X	X	X
58	Venus mercenaria Linné..............	V	X	X						X		X	X	X

Rare or Abundant in Pleistocene.	Depth Range of Living Representatives.	Kind of Shore or Bottom Preferred by Living Representatives.	Geographical Range of Living Representatives. Extreme Northern Range.	Extreme Southern Range.	
C	2–100	Sand, mud.	North Carolina.	Charlotte Hbr.	1
R	7–225		Rhode Island.	Sombrero.	2
VR	2–50	Mud.	Norway.	North Carolina.	3
R	15–65		Hatteras.	West Indies.	4
R	2–175		Hatteras.	Barbados.	5
R	1–20		Hatteras.	Antilles.	6
					7
A	2–10	Sandy Bot. and Sh.	Cape Cod.	St. Thomas.	8
R	5–116		Hatteras.	Brazil.	9
A			Hatteras.	Aspinwall.	10
A		Sand, shells, mud.	Cape Cod.	Trinidad.	11
R					12
A	2–10	Sand, mud.	Cape Cod.	Key West.	13
VR	10–180		Hatteras.	Venezuela.	14
NU		Fine sand, mud.	Cape Fear.	South America.	15
NU		Fine sand, mud.	Hatteras.	Guadaloupe.	16
NU	0–5	Mud bottom.	Prince Edward Is.	Florida Keys.	17
R		Mud.	Hatteras.	Guadaloupe.	18
R			Hatteras.	Brazil.	19
R			Hatteras.	Barbados.	20
R			Hatteras.	Trinidad.	21
A	0–12	Shelly Shore and Bot.	Nova Scotia.	Martinique.	22
VR			Arctic Sea.	Fort Macon, N. C.	23
VR	0–50	Mud, sand.	Charleston.	Brazil.	24
VR	0–80		Arctic Sea.	North Carolina.	25
R		Shells.	Maine.	Venezuela.	26
VR	6–18	Sand, mud.	Hatteras.	Gulf of Mexico.	27
A		Sand (?)	Hatteras.	Florida Keys.	28
VR		Mud, Br. Wtr.	South Carolina.	Cuba.	29
VR	0–30	Rocks, gravel.	Tampa.	Yucatan.	30
R	36–124	Rocks, gravel.	Hatteras.	Gulf of Mexico.	31
R	0–52		Hatteras.	Yucatan.	32
R	0–26		Cape Fear.	Antilles.	33
VA	2–640		North Carolina.	Brazil..	34
C	15–124		Hatteras.	Cuba.	35
C	5–85		North Carolina.	Porto Rico.	36
VA	8–287		Cape Lookout.	Grenada.	37
C	0–18		Hatteras.	Cuba.	38
A	10–54	Sand, gravel.	Massachusetts.	Trinidad.	39
C			Tortugas.	Jamaica.	40
R			Hatteras.	Rio Janeiro.	41
VR	14–294		Hatteras.	St. Thomas.	42
A		Sand.	Cape May.	Cuba.	43
C	1–4 ft.	Sea weeds.	Hatteras.	Trinidad.	44
R			Hatteras.	Trinidad.	45
R	0–100		Hatteras.	Guadaloupe.	46
VR	0–50	Sand, mud, Est.	Nova Scotia.	Brazil.	47
NU	–22	Sand.	Cape Lookout.		48
VR			Cedar Keys.	Charlotte Hbr.	49
VR	2–63		Maine.	Hatteras.	50
VR	18–22		North Carolina.		51
VR					52
C			Hatteras.	Cuba	53
A			New Jersey.	Vera Cruz.	54
A	–20		Cape Fear.	West Indies.	55
R	15–124		Hatteras.	Honduras.	56
NU	12–63		Hatteras.	Yucatan.	57
A	1–12	Sand, mud.	Nova Scotia.	Yucatan.	58

No.	SPECIES.	In Vanderbilt University Museum.	South Carolina Pleistocene Localities: Young Island.	Stono River.	Abapoola Creek.	Doctors Swamp.	Cainhoy.	Wando River.	Charleston.	Other Places.	Other Ages than Pleistocene: Pre-Miocene.	Miocene.	Pliocene.	Recent.
	Mollusca Pelecypoda.—Con.													
59	Venus mercenaria var. notata Say....		X							X		X	X	X
60	Venus campechiensis Gmelin..........	V	X	X								X	X	X
61	Petricola pholadiformis Lamarck.....	V	X	X										X
62	Petricola dactylus Sowerby...........		X											X
63	Petricola typica Jonas................	V	X										X	X
64	Tellina alternata Say.................	V	X	X	X								X	X
65	Tellina lintea Conrad.................	V	X	X										X
66	Tellina Sayi Deshays..................	V	X	X									X	X
67	Tellidora cristata Recluz.............	V	X	X						X			X	X
68	Strigilla flexuosa Say................	V	X	X							O	X	X	X
69	Macoma tenta Say......................	V	X										X	X
70	Macoma constricta Bruguière.........									X			X	X
71	Macoma balthica Linné................		X											X
72	Semele proficua Pulteney.............	V	X	X									X	X
73	Semele bellastriata Orbigny..........	V	X	X									X	X
74	Semele transversa Say................				X									
75	Abra aequalis Say.....................	V	X									X	X	X
76	Abra angulata Holmes.................	V	X	X	X				X				X	X
77	Cumingea tellinoides Conrad.........	V	X	X										X
78	Donax variabilis Say..................									X				X
79	Donax fossor Say......................	V	X	X								X	X	X
80	Ensis directus Conrad.................	V	X	X							E	X	X	X
81	Ensis minor Dall......................	V	X	X										X
82	Solen viridis Say.....................		X											X
83	Tagelus gibbus Spengler..............	V	X	X	X				X			X	X	X
84	Mactra fragilis Gmelin...............		X										X	X
85	Spisula similis Say...................	V	X	X										
86	Spisula soidissima Dillwyn...........	V		X										X
87	Mulinia lateralis Say.................	V	X	X	X					X		X	X	X
88	Mulinia lateralis Say var. b..........	V	X	X										
89	Mulinia Milesii Holmes (?)...........		X							X		X		
90	Rangia cuneata Gray..................								X				X	X
91	Labiosa canaliculata Say............	V	X											X
92	Labiosa lineata Say..................		X										X	X
93	Mesodesma concentrica Holmes.......		X	X						X				
94	Mya arenaria Linné..................		X		X							X		X
95	Paramya subovata Conrad............									X		X	X	X
96	Corbula contracta Say...............	V	X	X	X				X				X	X
97	Pholas campechiensis Gmelin.........		X							X				X
98	Barnea costata Linné................	V	X										X	X
99	Barnea truncata Say..................		X											X
100	Martesia cuneiformis Say............	V	X	X								X		X
101	Gastrochaena cuneiformis Spengler...	V	X							X			X	X
102	Xylotria palmilata Leach.............								X					X
103	Cyclinella tenuis Recluz.............	V		X									X	X

Rare or Abundant in Pleistocene.	Depth Range of Living Representatives.	Kind of Shore or Bottom Preferred by Living Representatives.	Geographical Range of Living Representatives. Extreme Northern Range.	Extreme Southern Range.	
R	1–12	Sand, mud shores.	Cape Cod.	Georgia.	59
C	1–12	Sand, mud Sh. and Bot.	Chesapeake Bay.	Cuba.	60
NU		Mud, clay.	Prince Edward Is.	St. Thomas.	61
R	4–6	Sand, shells.	Maine.	South Carolina.	62
R			Cape of Florida.	Antilles.	63
A			Hatteras.	Haiti.	64
R	0–30		Hatteras.	Jamaica.	65
C			North Carolina.	Yucatan.	66
NU			North Carolina.	Trinidad.	67
C	0–30		Hatteras.	Antilles.	68
R	2–87	Mud.	Cape Cod.	Rio Janeiro.	69
VR		Sand, mud Est.	New Jersey.	Brazil.	70
VR		Gravel, sand, mud.	Arctic Sea.	Georgia.	71
C			Virginia.	Guadaloupe.	72
VR			Hatteras.	Brazil.	73
VR					74
NU			Hatteras.	Gulf of Mexico.	75
C			North Carolina.		76
R	0–50	Gravel, sand, mud.	Prince Edward Is.	Guadaloupe.	77
R			Hatteras.	St. Thomas.	78
NU			New Jersey.	Florida Keys.	79
NU		Fine sand flats.	Labrador.	Florida.	80
NU		Fine sand flats.	Cape May.	Florida, Texas.	81
R		Sand.	Rhode Island.	Georgia.	82
R		Muddy Est.	Cape Cod.	Brazil.	83
R			Hatteras.	Brazil.	84
R					85
R	0–10	Sand.	Labrador.	West Indies.	86
VA		Mud, sand flats.	Massachusetts Bay.	Florida Straits.	87
VA					88
R					89
VA		Mud, Est., Br. Wtr.	Gulf of Mexico.	West Florida.	90
A			New Jersey.	Brazil.	91
R			New Jersey.	Brazil.	92
R					93
R	0–40	Sand Bch. and mud Inl.	Nova Scotia.	South Carolina.	94
R	12–31		Beaufort, N. C.	Florida.	95
NU	3–63	Gravel, shells.	Cape Cod.	Jamaica.	96
NU		Mud, sand.	Hatteras.	Brazil.	97
NU		Mud, sand.	Cape Cod.	Brazil.	98
R			Massachusetts.	South Carolina.	99
R	0–12		Connecticut.	Trinidad.	100
NU	0–25	Shell bottom.	Cape Fear.	Guadaloupe.	101
R		Boring in wood.	South Carolina.		102
VR	0–2	Sand.	Cedar Keys, Fla.	Brazil.	103

	SPECIES.	In Vanderbilt University Museum.	South Carolina Pleistocene Localities.								Other Periods than Pleistocene.			
			Young Island.	Stono River.	Abapoola Creek.	Doctors Swamp.	Cainhoy.	Wando River.	Charleston.	Other Places.	Pre-Miocene.	Miocene.	Pliocene.	Recent.
	Mollusca Gastropoda.													
1	Tornatina canaliculata Say	V	X	X	X	X						X	X	X
2	Planorbis lentus Say		X										X	X
3	Volva acicularis H. & A. Adams	V	X	X					X					
4	Melampus bidentatus Say									X				X
5	Terebra dislocata Say	V	X	X						X	E	X	X	X
6	Terebra concava Say	V	X										X	X
7	Terebra protexta Conrad	V	X									X	X	X
8	Mangilia cerina Kurtz & Stimpson	V	X	X			X							X
9	Cancellaria reticulata Linné		X					X						X
10	Oliva litterata Lamarck	V	X	X								X	X	X
11	Olivella mutica Say	V	X	X								X	X	X
12	Marginella limatula Conrad	V	X	X	X	X							X	X
13	Marginella apicina Menke	V	X	X									X	X
14	Mitra wandoensis Holmes							X					X	X
15	Fasciolaria distans Lamarck	V	X	X									?	X
16	Fasciolaria gigantea Kiener	V	X	X						X			X	X
17	Fasciolaria tulipa Linné	V	X							X			X	X
18	Fulgur pyrum Dillwyn	V	X									X	X	X
19	Fulgur carica Linné	V	X	X									X	X
20	Fulgur perversum Linné	V	X	X								X	X	X
21	Fulgur canaliculata Say		X										X	X
22	Fusus minor Holmes		X											
23	Fusus conus Holmes			X	X									
24	Fusus bullata Holmes		X											
25	Fusus filiformis Holmes		X											
26	Fusus rudis Holmes		X											
27	Tritonidia cancellaria Conrad	V	X	X										X
28	Tritonidia tincta Conrad	V	X											X
29	Nassa trivitata Conrad		X										X	X
30	Nassa acuta Say	V	X	X										X
31	Ilynassa obsoleta Conrad	V	X	X									?	X
32	Columbella ornata Ravenel	V	X	X			X							
33	Anachis avara Say	V	X	X										X
34	Astyris lunata Say	V	X	X			X							X
35	Murex pomum Gmelin	V		X						X		X	X	X
36	Eupleura caudata Say	V	X	X									X	X
37	Urosalpinx cinereus Say	V	X	X										X
38	Scala angulata Say	V	X	X										X
39	Scala Sayana Dall	V	X	X			X						X	X
40	Scala multistiata Say		X											X
41	Scala lineata Say	V	X	X										X
42	Eulima conoidea Kurtz & Stimpson	V	X	X								?	X	X
43	Pyramidella crenulata Holmes	V	X	X									X	X
44	Turbonilla interrupta Totten	V	X	X			X	X		X		X	X	X
45	Turbonilla nivea Stimpson	V	X	X	X	X	X						X	X
46	Turbonilla reticulata C. B. Adams	V	X	X			X	X				X	X	X
47	Turbonilla speira Ravenel	V	X	X			X							
48	Turbonilla protracta Dall		X									X	X	X
49	(?) Turbonilla pupoides Orbigny		X										X	X
50	Turbonilla virgata Dall	V	X									X	X	X
51	Odontostomia impressa Say									X			X	X
52	Odontostomia seminuda C. B. Adams	V	X	X			X	X				X	X	X
53	Pyrula papyrata Say									X			X	X
54	Strombus pugilis Linné		X							X		X	X	X
55	Seila Adamsii H. C. Lea	V		X								X	X	X
56	Bittium cerithidioides Dall		X									X	X	X
57	Serpulorbis decussata Gmelin		X									X	X	X

Rare or Abundant in Pleistocene.	Depth Range of Living Representatives.	Kind of Shore or Bottom Preferred by Living Representatives.	Geographical Range of Living Representatives. Extreme Northern Range.	Geographical Range of Living Representatives. Extreme Southern Range.	
VA	0–63	Muddy Shore and Bot.	Cape Cod.	Florida Keys.	1
R		Stagnant Water.	Massachusetts.	Florida.	2
VR					3
R		Swamps, Br. Water.	Massachusetts Bay.	Gulf of Mexico.	4
A			Maryland.	Venezuela.	5
NU			Hatteras.	Georgia.	6
NU	2–50	Weedy Bot.	Hatteras.	Texas.	7
A	3–10	Mud.	Cape Cod.	Fernandina.	8
R	5–30		Hatteras.	Guadaloupe.	9
A	0–2	(?) Sandy beaches.	Hatteras.	West Indies.	10
C			North Carolina.	Trinidad.	11
C	25–100	Sand and gravel.	Hatteras.	South Carolina.	12
R			Hatteras.	Jamaica.	13
VR	12–60	Gravel.	Hatteras.	Gulf of Mexico.	14
R	0–54		North Carolina.	Florida, Texas.	15
R	0–10		Hatteras.	Carthagena.	16
R	0–10		Hatteras.	St. Thomas.	17
R	0–50	Sand.	Hatteras.	Gulf of Mexico.	18
NU	0–10	Rocks, Gravel, sand.	Cape Cod.	Gulf of Mexico.	19
R	0–3		Hatteras.	Gulf of Mexico.	20
R			Cape Cod.	Gulf of Mexico.	21
R					22
R					23
R					24
R					25
R					26
C			Jupiter Inlet.	Darien.	27
VR			Hatteras.	Vera Cruz.	28
NU	0–40	Sandy Sh. and Bot.	Nova Scotia.	St. Augustine.	29
C			North Carolina.	Barbados.	30
C	0–10	Mud, Br. Water.	Nova Scotia.	Tampa.	31
C					32
C	0–10	Rocks, shells.	Massachusetts Bay.	Florida Keys.	33
C	0–12	Rock, shell, weeds.	Prince Edward Is.	Florida Keys.	34
VR			North Carolina.	Antilles.	35
NU	1–3	Muddy shore.	Cape Cod.	Florida Keys.	36
R	0–10	Rocks, shells.	Nova Scotia.	St. Augustine.	37
C		Sand, mud.	Connecticut.	Texas.	38
C	5–40		Virginia.	Key West.	39
NU		Shelly.	Cape Cod.	South Carolina.	40
C		Shelly and muddy.	Cape Cod.	Charlotte Harbor.	41
R	–8	Muddy Bot.	Hatteras.	West Indies.	42
A	0–2	Muddy flats.	Hatteras.	St. Thomas.	43
FA	2–107	Shelly Bot.	Nova Scotia.	Barbados.	44
FA	10–40	Muddy Bot.	Maine.	South Carolina.	45
C	0–60		North Carolina.	Jamaica.	46
C					47
NU	15–63		North Carolina.	Santo Domingo.	48
R				Jamaica, Cuba.	49
NU	12–80		North Carolina.	Florida.	50
R			Massachusetts Bay.	St. Augustine.	51
NU	2–10	Shells, gravel.	Prince Edward Is.	Florida Keys.	52
R			North Carolina.	West Indies.	53
R			Hatteras.	Aspinwall.	54
VR			Massachusetts.	West Indies.	55
R			Cape Lookout.	Santo Domingo.	56
R	–22		North Carolina.	Antilles.	57

No.	SPECIES.	In Vanderbilt University Museum.	South Carolina Pleistocene Localities. Young Island.	Stono River.	Abapoola Creek.	Doctors Swamp.	Cainhoy.	Wando River.	Charleston.	Other Places.	Other Periods than Pleistocene. Pre-Miocene.	Miocene.	Pliocene.	Recent.
	Mollusca Gastropoda.—Con.													
58	Littorina irrorata Say................	V	X	X			X					X	X	X
59	Solarium granulatum Lamarck.......		X									X	X	X
60	Adeorbis Holmesii Dall...............	V	X									X		
61	Calyptraea centralis Conrad..........		X									X	X	X
62	Crepidula fornicata Linné............	V	X	X								X	X	X
63	C. aculeata Gmelin var. costata Linné	V		X	X	X						X	X	X
64	Crepidula convexa Say..............	V	X										X	X
65	Crepidula plana Say..................	V	X	X								X	X	X
66	Natica pusilla Say....................	V	X	X									X	X
67	Polynices duplicatus Say.............	V	X	X								X	X	X
68	Polynices heros Say [Verrill].......								X			X	X	X
69	Sigaretus perspectivus Say............	V	X	X										X
70	Angaria crassa Holmes................		X	X										
71	Cochliolepis nautiliformis Holmes....						X	X				X		X
72	Vitrinella multicarinata Stimpson....						X	X				X	X	X
73	Fissuridea alternata Say.............	V	X	X									X	X
74	Cavolinia gibbosa Rang (?)..........		X											X
75	Chiton apiculatus Say.................		X											X
76	Balanus perforatus (Bruguière) Darwin..............................	V	X	X										

Rare or Abundant in Pleistocene.	Depth Range of Living Representatives.	Kind of Shore or Bottom Preferred by Living Representatives.	Geographical Range of Living Representatives. Extreme Northern Range.	Geographical Range of Living Representatives. Extreme Southern Range.	
NU	0–10	Mud, estuaries.	Rhode Island.	Jamaica.	58
R	–deep		Hatteras.	West Indies.	59
R					60
R			Hatteras.	South America.	61
C	0–15	Shells, gravel.	Prince Edward Is.	South America.	62
R	0–589		Cape Lookout.	Barbados.	63
C	0–22	Shells.	Nova Scotia.	Florida.	64
C	0–487	Shells.	Prince Edward Is.	Trinidad.	65
C	2–15	Sand, shells.	Massachusetts.	Florida Keys.	66
A		Sand, mud beaches.	Massachusetts Bay.	Vera Cruz.	67
VR	0–40	Sand, mud beaches.	Gulf of St. Lawrence.	Georgia.	68
NU			New York.	Martinique.	69
VR					70
R			South Carolina.	Florida Keys.	71
R	0–15		Hatteras.	Florida.	72
NU	1–50		Hatteras.	Barbados.	73
R	Pelagic		North Lat. 43°.	North Lat. 41°.	74
VR			Massachusetts.	South Carolina.	75
					76

3. Lists of Pleistocene Fossils From Other States.

a. Florida.

1. *Ameria scalaris* Dall.
2. *Tornatina canaliculata* Say.
3. *Bulla striata* Bruguière.
4. *Terebra concava* Say.
5. *Terebra protexta* Conrad.
6. *Terebra dislocata* Say.
7. *Conus pygmaeus* Reeve.
8. *Mangilia plicosa* Adams.
9. *Mangilia cerinella* Dall.
10. *Oliva litterata* Lamarck.
11. *Olivella mutica* Say.
12. *Marginella apicina* Menke.
13. *Marginella minuta* Pfeiffer.
14. *Fasciolaria gigantea* Kiener.
15. *Fasciolaria distans* Lamarck.
16. *Fasciolaria tulipa* Linné.
17. *Fulgur perversum* Linné.
18. *Fulgur pyrum* Dillwyn.
19. *Melongena corona* Gmelin.
20. *Tritonidea tincta* Conrad.
21. *Nassa vibex* Say.
22. *Anachis avara* Say.
23. *Astyris lunata* Say.
24. *Urosalpinx perrugatus* Conrad.
25. *Urosalpinx tampaensis* Conrad.
26. *Eupleura caudata* Say.
27. *Eupleura caudata var sulcidentata* Dall.
28. *Muricidea multangula* Philippi.
29. *Scala lineata* Say.
30. *Scala Frielei* Dall.
31. *Pyramidella crenulata* Holmes.
32. *Eulimella* sp.
33. *Turbonilla interrupta* Totten.
34. *Turbonilla* sp.
35. *Odontostomia caloosaensis* Dall.
36. *Odontostomia conoidea* Brocchi.
37. *Odontostomia fusca* C. B. Adams.
38. *Odontostomia* sp.
39. *Pyrula papyrata* Say.
40. *Strombus pugilis* Linné.
41. *Cerithium murcarum* Say.
42. *Vermetus irregularis* Orbigny.
43. *Vermetus varians* Orbigny.
44. *Vivapora georgiana* Lea.
45. *Ampullaria hopotonensis* Lea.
46. *Rissoa callistrophia,* var. Dall.
47. *Crepidula fornicata* Say.
48. *Crepidula convexa* Say.
49. *Crepidula plana* Say.
50. *Natica pusilla* Say.
51. *Polynices duplicata* Say.
52. *Teinostoma cryptospira* Verrill.
53. *Achanthocites spiculosus* Reeve.
54. *Fissuridea alternata* Say.
55. *Arca secticostata* Reeve.
56. *Arca occidentalis* Philippi.
57. *Arca umbonata* Lamarck.
58. *Arca ponderosa* Say.
59. *Scapharca transversa* Say.
60. *Pinna carnea* Gmelin.

61. *Atrina rigida* Dillwyn.
62. *Atrina serrata* Sowerby.
63. *Ostrea virginica* Gmelin.
64. *Pecten exasperatus* Sowerby.
65. *Pecten ornatus* Lamarck.
66. *Pecten gibbus* Linné.
67. *Pecten gibbus* var. *dislocatus* Say.
68. *Pecten gibbus* var. *irradians* Lamarck.
69. *Spondylus echinatus* Martyn.
70. *Anomia simplex* Orbigny.
71. *Modiolus demissus* Dillwyn.
72. *Cardita domingensis* Orbigny.
73. *Cardita floridana* Conrad.
74. *Venericardia tridentata* Say.
75. *Venericardia perplana* Conrad.
76. *Cyrena floridana* Conrad.
77. *Cyrena caroliniana* Bosc.
78. *Sportella constricta* Conrad.
79. *Codakia orbicularis* Linné.
80. *Lucina chrysostoma* Philippi.
81. *Phacoides pectinatus* Gmelin.
82. *Phacoides muricatus* Spengler.
83. *Phacoides multilineatus* Tuomey and Holmes.
84. *Phacoides floridana* Conrad.
85. *Phacoides nassula* Conrad.
86. *Cardium isocardia* Linné.
87. *Cardium robustum* Solander.
88. *Cardium muricatum* Linné.
89. *Cardium spinosum* var. *spinosum* Meuchen.
90. *Cardium serratum* Linné.
91. *Cardium Mortoni* Conrad.
92. *Montacuta floridana* Dall.
93. *Diplodanta punctata* Say.
94. *Dosinia discus* Reeve.
95. *Dosinia elegans* Conrad.
96. *Transennella Conradina* Dall.
97. *Transennella caloosana* Dall
98. *Macrocallistra nimbosa* Solander.
99. *Chione cancellata* Linné.
100. *Anomalocardia caloosana* Dall.
101. *Anomalocardia brasiliana* Gmelin.
102. *Venus campechiensis* Gmelin.
103. *Parastarte triquetra* Conrad.
104. *Angulus versicolor* Cozzens.
105. *Angulus sybariticus* Dall.
106. *Tellina umbra* Dall.
107. *Tagelus gibbus* Spengler.
108. *Tagelus divisus* Spengler.
109. *Donax variabilis* Say.
110. *Gemma gemma* var. *purpurea* Lea.
111. *Labiosa canaliculata* Say.
112. *Rangia cuneata* Gray.
113. *Mulinia lateralis* Say.
114. *Mulinia lateralis* var. *corbuloides* Reeve.
115. *Ervilia concentrica* Gould.
116. *Congeria lencophaeata* Conrad.
117. *Pholas campechiensis* Gmelin.
118. *Barnea costata* Linné.
119. *Gastrochaena cuneiformis* Spengler.

b. Cornfield Harbor, Maryland.

1. *Actaeon melonoides* Conrad.
2. *Tornatina canaliculata* Say.
3. *Mangilia cerina* Kurtz and Stimpson.
4. *Nassa trivitata* Say.
5. *Ilynassa obsoleta* Say.
6. *Fulgur carica* Linné.
7. *Fulgur pyrum* Dillwyn.
8. *Astyris lunata* Say.
9. *Urosalpinx cinereus* Say.
10. *Eupleura caudata* Say.
11. *Scala Sayana* Dall.
12. *Scala lineata* Say.
13. *Turbonilla interrupta* Totten.
14. *Turbonilla reticulata* C. B. Adams.
15. *Odontostomia seminuda* Adams.
16. *Crepidula plana* Say.
17. *Crepidula fornicata* Say.
18. *Crepidula convexa* Say.
19. *Polynices duplicatus* Say.
20. *Nucula proxima* Say.
21. *Leda acuta* Conrad.
22. *Yoldia limatula* Say.
23. *Arca ponderosa* Say.
24. *Scapharca transversa* Say.
25. *Mytilus hamatus* Say.
26. *Pandora triliniata* Say.
27. *Callocardia Sayana* Conrad.
28. *Venus mercenaria* Linné.
29. *Venus mercenaria* var. *notata* Say.
30. *Petricola pholadiformis* Lamarck.
31. *Macoma balthica* Linné.
32. *Macoma Virginiana* Conrad.
33. *Ensis directus* Conrad.
34. *Tagelus gibbus* Spengler.
35. *Mulinia lateralis* Say.
36. *Mulinia lateralis* Say var. b.
37. *Rangia cuneata* Gray.
38. *Mya arenaria* Linné.
39. *Corbula contracta* Say.
40. *Barnea costata* Linné.
41. *Dentalium* sp.
42. *Foraminifera.*

c. Sankoty Head, Massachusetts.

1. *Buccinum undatum* Linné.
2. *Ilynassa obsoleta* Conrad.
3. *Crucibulum striatum* Say.
4. *Fusus scalariformis* Stimpson.
5. *Urosalpinx cinereus* Say.
6. *Cerithiopsis Greenii* C. B. Adams.
7. *Odostomia trifida* Gould.
8. *Turbonilla interrupta* Totten.
9. *Margarita obscura* Gould.
10. *Caecum pulchellum* Stimpson.
11. *Rissoa aculeus* Stimpson.
12. *Crepidula fornicata* Say.
13. *Crepidula plana* Say.
14. *Crepidula convexa* Say.
15. *Skenea planorbis* Forbes and Hanley.
16. *Polynices heros* Say.
17. *Arca pexata* Say.
18. *Scapharca transversa* Say.
19. *Mytilus hamatus* Say.

20. *Modiolus modiolus* Linné.
21. *Venericardia borealis* Conrad.
22. *Cyclocardia novangliae* Morse.
23. *Ostrea Virginica* Gmelin.
24. *Anomia aculeata* Gmelin.
25. *Astarte undata* Gould.
26. *Astarte castanea* Say.
27. *Astarte quadrans* Gould.
28. *Venus mercenaria* Linné.
29. *Venus mercenaria* var. *notata* Say.
30. *Ensis directus* Conrad.
31. *Ceronia arctata* H. and A. Adams.
32. *Spisula solidissima* Dillwyn.
33. *Mesodesma Jamesii.*
34. *Cumingia tellinoides* Conrad.
35. *Mya arenaria* Linné.
36. *Panopea* sp.
37. *Balanus eburneus* Gould.
38. *Balanus porcatus.*
39. *Panopeus* (claws).
40. *Clione sulphurea* Verrill (sponge).
41. *Serpula dianthus* Verrill (Annelid).

4. Discussion of and Conclusions from the Tables.

According to Tuomey, at White Point Creek in northeastern Horry, very near the ocean shore line, there is a deposit of shells among which are *Venus mercenaria, Ostrea Virginica, Scapharca incongrua, Arca Noae* and a species of *Pectunculus.* This deposit is doubtless Pleistocene, as he claimed. Again Tuomey gives a short list of fossils from Laurel Hill bluff, northeastern Georgetown County, which includes *Arca ponderosa, Scapharca campechiensis, Mulinia lateralis, Spisula similis, Donax variabilis, Rangia cuneata,* and *Oliva litterata.* It is interesting to note that the fossil bed here is eight feet above tide, the highest elevation yet known for the Pleistocene fossil deposits of the State. At other places in Georgetown County southward from Laurel Hill, especially along Winyah Canal, characteristic Pleistocene fossils have been found. These localities in the northern part of the Coastal belt of the State, combined with two or three others mentioned by Tuomey as occurring in northern Charleston County, together with the localities listed in these tables, show plainly that along the entire shore of the State the deposits of Pleistocene fossils surely extend from White Point Creek in the north to Beaufort, and probably beyond toward the south, in one continuous sheet, except where cut through by streams.

As to the ages in which these species occur, it is seen that at least 95 per cent of them, as known certainly, live along the coast today. It is possible that the percentage will run higher when more thorough

investigations have been made into the present fauna of the southeastern Atlantic coast of the United States. But, as it is, we have a reconfirmation that the beds here considered are without doubt Pleistocene. It is further seen that about 60 per cent. of these Pleistocene species are also found in the Pliocene of the neighboring regions. This shows that the transit from Pliocene to Pleistocene times and conditions brought no great or sudden changes with it in South Carolina. The probability is that, with the advance of the ice-sheet from the north into the latitude of New Jersey, the accompanying cold was a long time reaching South Carolina, and there was no widespread destruction of Pliocene forms on this part of the coast whatever may have been the effect produced farther north. This phase of the subject will come up later in the discussion, and need not be dwelt upon here. It may also be observed that about 30 per cent. of the species are also Miocene. This is about what we might expect if there had been no great or sweeping changes, and if only the ordinary forces of evolution had been at work combined with moderate changes in environment. Only occasionally is a form seen to run back into the Oligocene or the Eocene—one proof that the transition from Oligocene to Miocene conditions was accompanied by influences more destructive to life than have been those of any transition since that time.

In accord with well-recognized and almost universally adopted principles, it is assumed, without taking the time to prove it, that any given species lives under approximately similar conditions of temperature, depth, shore or bottom, salinity, current, or other environmental condition in whatever geologic age it has been found. For in case the species, as has just been said, should little by little be changed with gradual advances into a distinctly different habitat to such a degree as to be clearly distinguishable from what it was originally, then it comes to be no longer regarded as the same species, but as a new species, distinct from the old. Therefore, with respect to the matter in hand, it is safe to assume that a species had, in the main, the same conditions of temperature, the same kind of bottom, the same fondness for or aversion to salt water or brackish water, or to a shore of vigorous waves or a region of quiet, or to shallow water or deeper, etc., in the Pleistocene Period that it has today. Now, these conditions for recent forms have been fairly well worked out by Verrill and Smith on the southeastern coast of New England, and by others along the Atlantic coast farther south, whose work has been tabulated by Dall in *Bulletin* 37 of the *Proceedings of the Na-*

tional Museum, and given by him in describing species in the *Transactions of the Wagner Free Institute of Science.* These have been the publications most relied upon in making out depth and geographic ranges for the living forms. The literature available has not always contained the results of the latest discoveries concerning the habitat of recent species. When these discoveries are made known, this table, especially in the columns headed "Geographical Range," may be somewhat modified.

Concerning Depth.—Of all the conditions of habitat, none is of much greater influence upon a form than depth. From the investigations of Verrill and Smith along the southeastern coast of New England, it is seen that each *zone* of depth, if that word can be so employed, has its peculiar life-forms, which, should they migrate much beyond their proper depth range, would perish. Of course, many forms live equally well in two or more zones, but others seem to be confined to one particular depth zone, especially such forms as live between tides. The main reason that depth is an important factor in the distribution of life-forms is that variations in depth in sea water brings about a variation in temperature, though variation in pressure, too, is not to be underestimated. Again, in shallow bays and estuaries the water is subjected to greater extremes of heat and cold than is the case on the open coast at equal depths, and only certain forms can adapt themselves to these marked extremes. At certain stages of its existence, a species would be killed by a lowering of the temperature of the water by 5° F., or even less. Brooks's experiments in Chesapeake Bay showed that a fall of 2° F. in the temperature of the water killed all the swimming larvae of *Ostrea virginica.* A rise of twice that many degrees, remarks Dall, would probably have only hastened their development. The general rule is that "it is always easier for a cold-water invertebrate to survive in warmer water than it is accustomed to than for one belonging to warm waters to persist when there is a change to a lower temperature." An increase in depth brings about a lowering of the temperature, and this is the ground for the importance attached to depth range. Now a study of the tables shows that most of the species of which record is had belong to the shallow-water zone exclusively, only 30 out of the 179 species listed ranging over fifty fathoms in depth, and some of these very little over the fifty-fathom line. Only thirteen species range deeper than the 100-fathom line, and these show a preferred range much shallower than that, as the following list clearly shows:

Pteria colymbus, 10-180, usually shallow; *Diplodanta semiaspera,*

14-294; *Glycymeris pectinata,* 2-175; *Leda acuta,* 7-225; *Barbatia Adamsii,* 5-116; *Phacoides amantus,* 2-640; usually shallow; *Phacoides crenulatus,* 15-124; *Phacoides multilineatus,* 8-287; *Venericardia tridentata,* 36-124; *Chione cribraria,* 15-124; *Turbonilla interrupta,* 2-107; *Crepidula aculeata* var. *costata,* 0-589, commonly 0-25; *Crepidula plana,* 0-487, usually shallow. Also, it must be taken into account that *Pteria colymbus, Diplodanta semiaspera* and *Venericardia tridentata* are very rare forms, and that *Leda acuta, Glycymeris pectinata, Barbatia Adamsii, Chione cribraria,* and *Crepidula aculeata* var. *costata* are almost as rare in the Pleistocene of South Carolina. This fact could be interpreted to mean that these forms may even have had their preferred habitat close to the lower limit in depth, and yet a few individuals have lived in shallow water; but we have record, in case of two of them, that they prefer the shallower depths. Two other of these species are seen to have a very wide geographical range: *Turbonilla interrupta* from Nova Scotia to the Barbados, and *Crepidula plana* from Prince Edward Island to Trinidad. Now, the general rule for a species migrating southward is to seek the cooler waters it is accustomed to by sinking deeper and deeper. The probability is that these two forms reach their greatest depth range much farther south than along the South Carolina coast. The other three species are all *Phacoides,* and it is well known that one of them, *Phacoides amiantus,* usually lives in shallow waters. Now, in the absence of contradictory evidence, it is usually safe to assume that what is preferred by one species of a genus is probably preferred by the others. So the three species of *Phacoides* may be considered as preferring shallow waters. Of the seventeen forms having their maximum depth range between fifty and one hundred fathoms, some are rare and others very rare, and need not be given too much weight; and the others still have abundant opportunity, without an exception, of having a much shallower habitat than fifty fathoms, almost all of them having an upper range of eight fathoms or less. It seems true, then, that on the whole these species today prefer a shallow water habitat, many of them living between tides even, as the absence of depth figures, following Dall, may generally mean. They constitute what may be called a littoral facies. The conclusion from this study of depth is that the Pleistocene species of South Carolina lived, on the whole, in shallow water and constituted a *littoral facies.* The value of this conclusion will be more evident later, when we come to consider geographical range.

Concerning Shore and Bottom Conditions.—Investigations show that bays and other partially inclosed bodies of sea water maintain a different aggregation of life-forms from that found out on the open coast, where the waves are more vigorous and life more strenuous. The group of animals on sandy bottom is markedly different from that on muddy bottom; so also do rocky and shelly bottoms differ from each other in the kind of animals they maintain and from the other kinds of bottom mentioned. The same holds good for the shores; they differ from one another and from the various kinds of bottom in the species preferring them. Of course, some species appear to thrive equally well on two or more kinds of bottom or shore; but, on the other hand, each kind of bottom or shore has its own peculiar characteristic species. In general, it may be asserted with some degree of assurance that all the species of any one genus, if there is nothing known to the contrary, prefer similar shore or bottom conditions. For example, if *Scapharca transversa* is always found preferring sandy shores, it is not far wrong to say that other species of *Scapharca* very like also prefer sandy shores. In the tables, however, this supposition has not been employed, and any word used in describing the kind of shore or bottom inhabited by any species is given on the authority of such workers as Verrill, Dall, Gould, Say, Binney, Fisher, Walther and Tryon. In discussing this phase of the subject, however, it does not seem amiss to employ the supposition just mentioned. Again, the kind of material upon which the marl beds rest and which is mixed in with the shells as they are exposed today, where there is evidence to suppose that these shells have not been carried by currents and deposited as they are found, but occupy the same position in the main today that they occupied when they were living in Pleistocene times—then, let it be said, this material must be taken into account and given serious weight in drawing conclusions concerning the shore and bottom of the Pleistocene seas and bays.

From the tables it seems that about thirty species of the entire number are found living in mud. Of this number, nineteen prefer the mud to any other kind of bottom, and thirteen seem to be found only on muddy bottom, and six are found in the mud of estuaries or other places of brackish water. More than half the mud-loving species are the only species of their respective genera, and so can be of little weight in attributing this characteristic to others of their genera. Forty-six species are found to live on sandy or gravelly bottom or shore, and of these, twenty-nine prefer sand above all

other kinds, and thirteen are found living only in sand. Here, for the most part, among the sand-lovers, each species is not the only one of its genus, as is the case with more than half the mud-lovers. So there is this evidence that a good many more species live in the sand than in the mud. A few species prefer shelly bottom, and occasionally one is mentioned as having been found on rocky bottom or shore, but never rocky *alone*—always some other kind in addition to the rocky. This is well, for there is no evidence of a rocky shore's existing along the South Carolina coast either in Recent or Pleistocene times. It is seen at Young Island and Stono River, the two places which furnish by far the greater number of species, that the beds of shells have quantities of sand containing mud or clay mixed with them. At one or two other places in the State the mixed-in material is pretty much all mud or clay, as is the case at Maxyck Ferry on the Santee, where a few species, like *Mulinia lateralis,* have been found. This is just what our tables would lead us to expect. So the conclusion here, as reached by a study of life-forms and of actual beds as found, is that, though mud-loving species are found in abundance, and also some lovers of shelly bottom, yet the weight of evidence is in favor of a sandy bottom and shore for the Pleistocene sea. Before leaving this phase of the subject, it is well to note that, of the mud-loving forms, some species are very abundant as Pleistocene fossils. *Rangia cuneata* is found in very great abundance underneath Charleston, whole beds being made up of it down about fifteen feet beneath the surface. Now, this is one of the estuarine forms, and probably indicates that at one time during the Pleistocene Period, the Ashley and Cooper rivers flowing into a somewhat landlocked bay as they do today, there was much mud and brackish-water conditions that just suited *Rangia cuneata.* Up the Potomac from Cornfield Harbor, Maryland, about eighteen miles, is found an extensive bed of this species. Now, at Cornfield Harbor, *Rangia cuneata* is found, but is rare. The supposition here is that the water was brackish enough at that distance up what was then an estuary as to just suit this species and too brackish for much of anything else, that while the deposit was being formed at Cornfield Harbor under marine conditions that farther up the river was being formed under estuarine conditions. In regard to the South Carolina Pleistocene forms, it may be said that *Rangia cuneata* is only one of a half-dozen that may have had just such estuaries with brackish water to live in. With the exception of this species, the estuarine species are not at all abundant in the Pleistocene localities of the State; indeed, three of

them are very rarely found. The indication, then, is against any extensive development of estuaries in South Carolina during Pleistocene times.

Concerning Geographical Range.—The eastward and westward migration of species along shore is in general more easily done than is the migration northward and southward. In the former case, the temperature, which is the most potent factor by far in influencing faunal distribution, remains practically constant, except for changes due to currents in the sea and to fresh-water streams from the land; while, in the latter case, the northward and southward extent of shore line, temperature continually changes with latitude, and also the currents and rivers play an important role in modifying temperature. It is not so difficult for a northern shallow-bottom species that is not littoral to migrate southward to a considerable distance, for it can always seek cooler waters by sinking into deeper depths as the southward migration is continued. But it is almost impossible for a southern shallow-bottom species to migrate very far northward, because it cannot find water of accustomed temperature by rising to more shallow depths, being already in shallow depths. The force of these remarks is plainly evident when it is recalled that the Pleistocene forms were essentially shallow-water forms. They were, therefore, as much limited in their north and south range then by reason of depth conditions as they are today. Furthermore, such species as live between tides and such as are strictly shore forms, getting their food under such conditions, are very much restricted in north and south range, for in this case the privilege of seeking cooler depths as it moves southward is denied the more northern form.

Also, there is more likelihood of change in bottom conditions close in shore than farther out at deeper depths; or, putting it the other way, conditions of bottom are more constant at some little distance out than near shore line, where every little inlet has its influences. These things combined point to the fact that the Pleistocene species, no more free to migrate than their living representatives today, can be taken as a safe means for interpreting what must have been the temperature in the Pleistocene Period in the particular latitudes in which they are found fossil.

Before turning again to the tables, there is another factor affecting distribution of marine fauna that must be spoken of, and that is the influence of currents. In this particular case, the influence of the warm Gulf Stream and of the cold Arctic Current has to be considered. In the neighborhood of Cape Hatteras, according to Dall, close

in shore, owing to the cooling effect of the Arctic Current, there are many forms that belong more strictly farther north; while off shore, maybe at no great distance, there are southern forms brought northward beyond their limit by the warm waters of the Gulf Stream. In this way are brought together, in closely adjoining regions, two distinct facies—forms which, without the influence of currents, would have their proper habitat hundreds of miles apart. Sharp points of land jutting out into the sea for several miles, in some cases many miles, often mark the limit in range of certain forms, especially those that love the simple life, preferring a quiet, shallow-water habitat; for, in attempting to round such a point, the form would be carried into depths it is unaccustomed to, or into bottom or shore conditions different from those hitherto surrounding it, or else out to where waves and currents are more vigorous than please its fancy. Cape Cod, Cape Hatteras and Cape Fear are just such points along the Atlantic coast that mark the limit of range for a goodly number of species. Cape Hatteras, in addition, is the point where the Gulf Stream is deflected off shore as it flows northward, and is also the point where the Arctic Current, in its southward movement, ceases to be a surface current and sinks beneath the Gulf Stream. For the reason that Cape Hatteras marks the limit of so many forms in their migration, it has been taken as the dividing point between northern and southern forms. Those forms whose northern limit of geographical range is at Cape Hatteras, may be regarded as southern, while those whose corresponding southern limit is at Cape Hatteras may be regarded as northern forms. There can hardly be any objection made to taking Hatteras as this dividing point; for here it is, let it be remembered, that the line of separation between the warm along-shore current and the cold along-shore current exists.

With these remarks as prefatory to the discussion concerning geographical range, a close study of the tables will now be entered upon with the purpose of seeing what must have been the geographical range of Pleistocene forms. Of the 160 species whose ranges are known, eighty-eight have their extreme northern geographical range either at Cape Hatteras or some point south thereof, and may be classed as southern forms. This in itself, according to Fisher, would be sufficient to stamp the Pleistocene forms of South Carolina as constituting a southern facies, his law being that if more than 50 per cent. of any aggregation of marine fauna belong to any one facies, the whole aggregation may, in general terms, be placed under that facies. Here the percentage of strictly southern forms is fifty-five.

But this is no more than was to be expected. Unless there had been very unusual conditions of climate during the Pleistocene deposition, a region in the latitude of South Carolina could hardly be expected to have anything else than a southern facies of marine fauna. On the other hand, it is somewhat astonishing to find that, out of the 160 species, only one has its southern limit at Hatteras or at some point north thereof. This is *Aligena elevata,* and has its northern limit at Maine, and southern at Hatteras, most abundant in the region just south of Cape Cod on to New Jersey. Its depth range is 2-63 fathoms so far as is known. The probability is that it will be found farther south and in deeper water in some of the dredging that is being done. As said at the outset, it is easier for a cold-water form to move into warmer regions than for the opposite to take place. This supposition carries more credence when it is noticed that its northern range is only so far north as Maine, and its deepest depth range only sixty-three fathoms. Furthermore, its extreme rarity as a Pleistocene fossil in South Carolina, only one valve being found from several bushels of the material collected, would lead one not to attach too much importance to its being found in the Pleistocene so far south. There is a pelagic form described by Holmes under the name *Cavolinia Tuomeyii,* which has been questionably included in these tables as *Cavolinia gibbosa,* whose range limits are 43° N. to 41° N. This form cannot enter into the discussion; so likewise several other questionable forms. Turning again to the tables, it is seen that there are several species that may possibly be regarded as northern forms, though they do range farther south than to Cape Hatteras. These are: *Venus mercenaria* var. *notata,* Cape Cod to Georgia; *Petricola dactylus,* Maine to South Carolina; *Macoma balthica,* Arctic Sea to Georgia; *Mya arenaria,* Nova Scotia to South Carolina; *Barnea truncata,* Massachusetts to South Carolina; *Solen viridis,* Rhode Island to Georgia; *Scala multistriata,* Cape Cod to South Carolina; *Turbonilla nivea,* Maine to South Carolina; *Polynices heros,* Gulf of St. Lawrence to Georgia (on authority of Verrill); *Chiton apiculatus,* Massachusetts to South Carolina. But every one of these is seen to reach as far south as South Carolina, some beyond. If they do that today, there is no reason why they should have required a different climate in Pleistocene times to reach the latitude of South Carolina. Furthermore, the tables show that almost all these forms are shallow-water forms, as already discussed, and could have migrated southward more easily under a cooler climate than under a warmer one. If the climate had been much cooler in Pleistocene

times than today, these species would probably have pushed their way farther southward and be found in the Pleistocene deposits of Florida. A search into the Florida Pleistocene fossil list fails to show a single one of them there. So the supposition that the Pleistocene climate for South Carolina was cooler than that today loses this evidence. To offset these seemingly northern forms, we find a few species with northern limit on the South Carolina shore and ranging to the southward, namely: *Cyrene caroliniana,* South Carolina to Cuba; *Mytilus exustis,* Charleston to Brazil; *Xylotria palmilata,* South Carolina; *Pyramidella crenulata,* South Carolina to St. Thomas; *Cochliolepis nautiliformis,* South Carolina to Florida Keys. These are shallow-water forms even in their most southern range, and could not migrate far northward, according to the principle proposed at the beginning of the discussion of depth. Their northern range would be more limited under colder climate. Of the ten forms named as possible northern forms, eight are rare in their occurrence in the South Carolina Pleistocene, and the other two are by no means abundant. Of the five forms ranging from South Carolina southward, four are rare in the Pleistocene, but the fifth, *Pyramidella crenulata,* is abundant. This may be taken as a slight indication that these warm-water species were more at home in the region than were the species from cooler waters.

One more comparison, and then the general conclusions can be drawn. It is seen that three forms have their southern limit a little to the north of South Carolina, but still south of Cape Hatteras. These are *Yoldia limatula,* with a range from Norway to North Carolina; *Modiolus modiolus,* from the Arctic Sea to North Carolina, and *Mytilus edulis* from the Arctic Sea to Fort Macon, North Carolina. They are very rare in their occurrence in the beds under discussion. It is not unreasonable to suppose that, if these species had vitality enough to survive after rounding the Cape, they may have pushed their way farther south still. It may be said of them, as it was said of *Aligena elevata,* that it can be expected that dredgings will reveal them farther south than they have yet been found. To compare with these, there are six or seven species that have their northern limit to the south of South Carolina. These one may, in this connection call extreme southern forms. One of them, *Sportella constricta,* is questionably included in the tables, and will not be considered, as no correct conclusion could be drawn from questionable data. The other six are: *Diplodanta soror,* Tortugas to Jamaica; *Cyclinella tenuis,* Cedar Keys, Florida, to Brazil; *Cardita floridana,* Tampa to

Key West; *Rangia cuneata,* Gulf of Mexico to West Florida; *Petricola typica,* Cape of Florida to the Antilles; *Tritonidia cancellaria,* Jupiter Inlet, Florida, to the Isthmus of Darien. These deserve especial notice. *Diplodanta soror* is common in its occurrence in the Pleistocene of the State; and *Rangia cuneata,* as has already been pointed out, is very abundant indeed in the bed underlying Charleston. This last-named species, as has already been noticed, is found in abundance in Maryland up the Potomac from Cornfield Harbor. Its occurrence so abundantly so far north as Maryland is very remarkable, and must mean that, at some time during the Pleistocene Period, there was greater warmth in that particular region than today, or else that the brackish water has failed in some of the necessary conditions to sustain *Rangia cuneata.* The occurrence of these extreme southern forms, together with the abundance of the two just mentioned and also the *Tritonidia cancellaria* (on Stono River), almost compel the conclusion that the Pleistocene facies of South Carolina, if different from that of the coast today in the same region, was more southern.

General Conclusions from the Study of the Tables.—According to Dall, the Pleistocene of Florida shows a change for the cooler from the warm temperature of the Pliocene. He says further: "The Pleistocene [of Florida], though far from glacial as at the north, was a period of diminished sea temperatures and moderate elevation without perceptible tilting. The present epoch has witnessed a slight increase of sea temperatures and a very slight, probably continuous, elevation amounting in all to only a few feet." McGee may be quoted in this connection: "W. B. Rogers, Sanderson Smith, Cook, Cope, Kerr, Fontaine, Lewis, Chester and others believe it [the Columbia or Pleistocene of the whole coast] was deposited during a period of low temperature." McGee's view also was in accord with this belief. He says that Desor, whose view will be given later, drew his conclusions from too limited data. Conrad, in speaking of the Cornfield Harbor species, says: "Were it not for the presence of *Gnathodon cuneatus* [*Rangia cuneata*], *Mytilus hamatus* and *Arca ponderosa,* the group would not vary from that now inhabiting the coast as far north as Massachusetts; but the occurrence of these three bivalves indicates that a climate equivalent to that of Florida prevailed when the shells of this locality were living in the sea." But this view loses some of its force, since two of the forms he here mentions are known to live at present as far north as Long Island Sound and Cape Cod, namely:

Mytilus hamatus and *Arca ponderosa.* The other one of the three, *Rangia cuneata,* is the only form present that would indicate a higher temperature than at present prevails; but the abundance of this, as has already been pointed out, gives Conrad's statement considerable force, though it is hardly probable that the climate of Maryland in Pleistocene times was anything near so warm as is that of Florida today. Another fact that adds some weight to the view here expressed in regard to the Cornfield Harbor deposit is that, in addition to *Rangia cuneata,* there are two other forms whose northern range limit falls short of reaching the Cornfield Harbor latitude, stopping at or below Cape Hatteras. "In 1852 Desor reviewed the paleontology of the formation [Pleistocene] as developed from South Carolina to Sankoty Head and Point Shirley, noted that the fossils are 'nearly all referable to living species,' and that the deposit occupies only a very narrow zone, and inferred not only that it is marine but that the climate was warmer than now when it was deposited" (McGee). "Verrill more recently enumerated about sixty species from the deposits of Sankoty Head, of which those from the lower strata indicate warmer and those from the upper strata colder climate than the present" (McGee). Enough views have been quoted to show that there are various and conflicting opinions as to the climate prevailing in Pleistocene times. Almost all the more recent views embody the general assertion that the Pleistocene was a period of much lower temperature than the Pliocene and slightly lower than the present. However unwilling an inexperienced worker may be for the view he reaches to be opposed to that held by experienced workers in any particular field, the facts gained from the study of the tables just completed compel the writer to say that the weight of evidence seems to justify the opinion that, if the Pleistocene sea temperature differed at all from that of the present, it was slightly higher rather than slightly lower than that of the present. This would seem true in South Carolina, whatever it may have been elsewhere. Now, as has already been intimated, it may be that the results of more thorough study of the fauna of the Atlantic coast and more abundant dredging may change the conclusions here reached, but until such data have been acquired—if they ever are—the conclusions above stated would seem to be the ones best warranted by the data at present available.

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